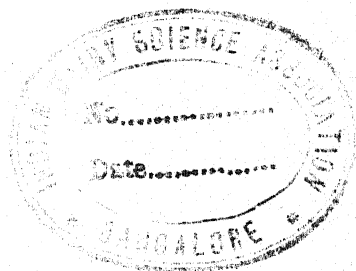


FEDERAL, STATE, AND LOCAL
ADMINISTRATIVE RELATIONSHIPS
IN AGRICULTURE



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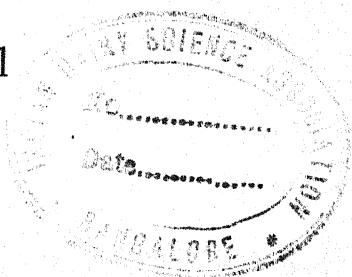


Federal, State, and Local Administrative Relationships in Agriculture

By Carleton R. Ball



VOLUME II



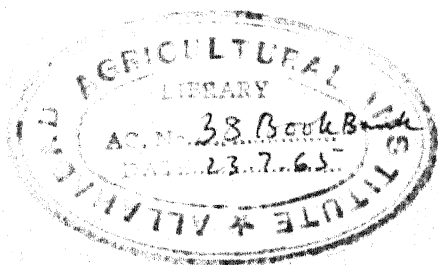
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Chapter VI: PLANT INDUSTRIES

[Because each chapter covers a different subject and therefore will be used chiefly by a different constituency, it seems desirable to make each one complete and self-contained. For this reason, among others, a complete table of chapter contents is placed at the beginning of each chapter, rather than at the front of the volume. A list of all literature cited in the chapter will be found at the end of the chapter and the numbers in parentheses in the text refer the reader to the corresponding entries in the list. All entry numbers occurring in each major section of a chapter are also listed in numerical sequence at the end of that section, thus forming what is in effect a section list of literature cited. These features all should prove of great convenience to readers.]

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Chapter VI

PLANT INDUSTRIES

1. INTRODUCTION

AGRICULTURE, the tilling of the fields, goes far back beyond the beginnings of recorded history. It is closely intertwined with the myths, traditions, songs, festivals, theology, and history of all peoples. Plant industry shares with animal industry the opportunity and obligation of producing most of the food and clothing of the human race. Plant industry has the greater task because it not only must produce the crops which supply food, clothing, and shelter, but also those which feed the animals that produce meat, milk, wool, leather, and eggs. Plant industries are much more sensitive to the effects of climate and soils (discussed in previous chapters) than are animal industries. Both are highly dependent on the science of chemistry, and some of these relations have been presented in the chapter on Agricultural Chemistry.

Some very marked differences between the beginnings of our improved plant industries and of our improved animal industries should be pointed out. Animals representing improved breeds of livestock and poultry were introduced almost entirely by private individuals. The introduction of new crop plants or of new varieties of known crop plants required official action or encouragement to be effective. The reasons for this marked difference are simple. Animals are but slightly influenced by soil and climate and therefore one breed properly may become distributed throughout the entire country, as for example the Jersey and Holstein breeds of dairy cattle. Plants, on the other hand, are greatly influenced by soil, climate, length of growing season, etc., and therefore their varieties usually are adapted only to regions, areas, or relatively small districts.

To obtain a supply of desirable improved animals adapted to a specific purpose, the individual farmer goes to recognized sources. To obtain plants adapted to new or old areas, intimate knowledge of comparative conditions of soil and climate in different parts of the world is necessary, and a search of distant and little-known



lands may be required. This the individual farmer cannot do and the action of official agencies becomes necessary.

Improved breeds or "varieties" of animals are few and the number of individuals likewise is small. The rate of increase is slow and the individuals are expensive. Hybridization can be and is controlled. The men who engage in livestock breeding, therefore, are few in number, well established, and their ability is widely known through reputation and advertising. The characteristics of the various breeds are known to farmers, the sources are few and well known, and the chances for innocent error or purposeful fraud are relatively slight. Exactly the opposite is true of plants. The number of named varieties is enormous. There is no definite series of "breeds" with recognized characters, and the opportunity for innocent error and intentional deception is enormous. Hybridization and mixing occur in nature and purity is difficult to maintain. Any farmer is a potential "breeder," and many thousands of them have distributed supposedly improved hybrids or selections by sale or gift. The rate of increase is exceedingly rapid and the number of individual plants is beyond simple mathematical calculation. A single field may contain more individuals of a wheat variety than the entire nation possesses of an improved animal breed. This rapid multiplication permits rapid dissemination through persuasive advertising, often carrying a variety into territory to which it is completely unsuited.

Productivity in animals is primarily a matter of breeding and only secondarily a matter of feeding and other handling. Productivity in plants is primarily a matter of soil and climate and only secondarily a matter of breeding. In the purchase of animals, recognized breeding is paramount, the complete individual is sold, and the purchaser may assure himself. In obtaining plants, a knowledge of adaptation is paramount, the sale usually is of seeds or cuttings, in which state a variety may not be recognized readily, and the purchaser is helpless to assure himself.

DEFINITION AND SCOPE

Plant Industries, as here discussed, cover crop production and improvement, and crop protection from diseases, insects, weeds, and other pests. Forest crops are omitted, however, because all matters

pertaining to forests will be presented in a chapter on Forest Resources, in the volume on Natural Resources.

Under the general term, *plant industries*, must be included much more than the mere growing of crops of various kinds. The complete range of activities will include plant introduction, crop geography and ecology, production methods, plant breeding, as well as plant physiology and crop protection, and tests and standards for quality of product. These activities also require close and extensive coöperations with official agencies in soils and chemistry, animal husbandry, agricultural engineering, agricultural economics, and home economics, and with various commercial agencies. Nor is this simple list completely self-interpreting.

The art of plant introduction, or bringing plants from distant areas, is a complex mixture of taxonomic botany, geology, soil technology, climatology, plant ecology, quarantine regulations, enthusiasm, persistence, personality, and luck. Production methods include soil handling, seed handling, and methods of seeding, cultivation, harvesting, and preparation for market. Plant breeding or improvement includes genetics, cytology, crop physiology, progeny selection, varietal comparisons, and quality testing, as well as mathematical and chemical interpretations of results. Crop protection covers the extermination or control of fungus diseases, insect pests, and weeds, as well as birds, rodents, and other animals injurious or destructive to crops. It likewise requires extensive applications of meteorological knowledge. These activities in turn require researches in chemistry, plant physiology, and ecology; insect and animal physiology and ecology; the composition, use, and effects of biocides (fungicides, insecticides, and other poisons); the physiological effects of transportation and storage of products, as well as the exercise of the entire machinery of plant, animal, and insect quarantines.

HISTORICAL DEVELOPMENT AND IMPORTANCE

Official attention was given to the developing of new plant industries during our colonial period. The British Government encouraged and sometimes subsidized the culture of indigo, mulberries for feeding silkworms, and other crops. After the Revolutionary War, orders were sent at different times to our consular and naval

officers to obtain new seeds and plants for use in America. The Congress made no provision, however, for receiving or distributing the imported material. A law providing for the issuing of patents for inventions had been passed in 1784 and a Patent Office established in the State Department. As the country was predominantly agricultural, it was only natural that many or most of the inventions should be concerned with agriculture and that men of agricultural knowledge and sympathies should be chosen as commissioners of patents.

In 1836, Hon. Henry L. Ellsworth, then Commissioner of the Patent Office, began to receive (although without any authority of law) the plants and seeds that were being sent from abroad, and to distribute them to enterprising farmers under the frank of interested congressmen. In 1837, he recommended to the Congress the creation of an agricultural agency for this specific task. In 1839, Congress appropriated the sum of \$1000 for agricultural purposes, including the procurement of cuttings and seeds for distribution among farmers. This appropriation was continued somewhat irregularly. In 1849 the Department of the Interior was established and the Patent Office transferred to it. The Agricultural Division of the Patent Office grew slowly until 1862, when the Department of Agriculture was created and all agricultural work consolidated in it.

Plant-industry units and activities were established in the new Department from time to time. The major ones created during the last century were the Propagating Garden, 1862; Fiber Investigations, 1863; Division of Entomology, 1863; Division of Botany, 1868; Division of Pomology, 1886; Division of Vegetable Physiology and Pathology, 1887; Division of Agricultural Soils, 1894; Division of Agrostology, 1895; and Office of Seed and Plant Introduction, 1900. The Bureau of Plant Industry was created on July 1, 1901. Other Divisions also had developed definite studies in the field of plant industries. For instance, the Division of Chemistry made far-reaching studies of the sorgo or saccharine sorghum plant during the eighties, in its search for a source of sugar. In the nineties it made a similar study of sugar-beet production. The Division of Soils made extensive field studies of the culture and improvement of tobacco, and the nature of enzyme action therein.

State departments of agriculture and State agricultural societies, which were organized so generally during the quarter century preceding the Civil War, gave large attention to the introduction of crop varieties and their distribution and testing. Extensive accounts of the results and descriptions of the varieties are found in their published proceedings. The State colleges of agriculture, founded in the several States before, or as a result of, the Land-Grant College Act of 1862, organized teaching departments of agriculture, horticulture, botany, and entomology, all of which were concerned with different aspects of plant industries. From 1887, the creation of a unified system of State agricultural experiment stations under the provisions of the Federal Hatch Act, provided agencies for increasing investigation of crop and other plants. The stations have developed divisions of agronomy (crops and soils), botany, horticulture, plant pathology, entomology, and landscape architecture, or of various combinations of these. The State colleges and experiment stations have received and distributed improved seeds and cuttings obtained by the Federal Department of Agriculture and in some cases have taken steps to obtain foreign material for themselves, either through correspondence or through visits of staff members abroad. They also exchange improved plants and seeds among themselves.

Plant Industries in California

In the course of years the plant industries of the United States have developed an enormous diversity, magnitude, and value. Without going into a discussion of these factors for the entire United States, it is proper to point out that California is unsurpassed among the States of the Union in the number, variety, and magnitude of her plant industries. They not only rank high in total value of the plant products themselves, but also are the basis of her important livestock, dairy, and poultry industries. According to the United States Census of 1930, California's crops had a total value of \$537,478,000 in 1929, without taking into account the pasturage consumed by her animal population, both domesticated and wild. This amount represented 6.7 per cent of the total crop value in the United States and a value of \$81.00 per acre.

Among the many crops produced in the State are representa-

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tives of nearly all of the commercial classes into which cultivated plants are grouped, including cereals, forages, fibers, oleogens (oil crops), sugar crops, fruits, nuts, truck and vegetable crops and seeds, drug and medicinal plants, and flowers, other ornamentals, and flower seeds.

The Federal Department of Agriculture has recognized the magnitude of the plant industries of California in its allotment of funds to its coöperative and independent work in that State. For 1931, the total expenditures in California by the four Bureaus concerned with plant production and protection were approximately \$635,000, to which must be added a relatively small amount expended by the Weather Bureau in crop-protection activities.

The California budget of the Bureau of Plant Industry in 1931 was about \$408,000, exclusive of the Divisions of Forest Pathology and Blister Rust Control which are concerned with forest protection and are reported under Forest Resources. The six Divisions of the Bureau of Entomology active in California crop protection had a budget of \$135,000 for the State. The estimated California budget of the Plant Quarantine and Control Administration was \$72,000, of which \$12,500 were applied to Mexican border inspection and about \$55,000 to date-scale eradication.

In the Bureau of Biological Survey, the Division of Predatory-Animal and Rodent Control spent \$5000 on control-methods research and about \$15,000 on the control of injurious rodents, or at the total rate of \$20,000 per annum. However, the expenditures by California State and county agricultural commissioners who co-operate in rodent control are estimated at about \$375,000 per annum, or twenty-five times as much as the Federal outlay. In addition, the annual expenditures by private individuals and companies for material, equipment, and labor is set at about \$500,000 per year. This makes a total expenditure of almost \$900,000 annually for the protection of plant industries from rodents alone. The average saving to the crop growers of California from these operations is estimated at about \$2,500,000 per annum.

AGENCIES AND RELATIONSHIPS

The official agencies concerned with plant industries are distributed in all four levels of government organization, Federal, State,

county, and municipal. There are extensive relations between the Federal and State agencies and between those of the State and county governments, but relatively few interrelations in other directions.

Federal Agencies

Naturally, the U. S. Department of Agriculture is the chief Federal agency to be concerned with plants. The Department of the Interior has some minor activities in this field, the Treasury Department a friendly interest, and the Smithsonian Institution one important part.

U. S. Department of Agriculture.—Under plant industries are included nearly all the activities of the Bureau of Plant Industry, most of those of the Bureau of Entomology and Plant Quarantine (formerly two separate bureaus), such of the duties of the Bureau of Biological Survey as relate to bird and rodent control for the protection of field, pasture, and orchard crops, and, finally, the crop-protection activities of the Weather Bureau. The Bureaus of Chemistry and Soils, Agricultural Economics, Agricultural Engineering, and Home Economics all have coöperative relations in some phases of the plant-industry problems.

Bureau of Plant Industry: This Bureau was created on July 1, 1901, to include the various Divisions and Offices named in the foregoing discussion of Historical Development. Numerous divisions have since been established. In general, these were called Offices until 1931 and have been designated as Divisions since that time. For the first several years the policy of the new Bureau was to increase the number of its units by successive subdivisions and additions. In recent years the tendency has been in the opposite direction and some larger units have been formed by the consolidation of smaller ones.

This multiplication of divisions resulted in or was accompanied by a duplication of activities in certain lines of work. Plant introduction was actively conducted by the two Divisions of Foreign Plant Introduction, and Cotton, Rubber, and Other Tropical Plants. Maize breeding was conducted by Cereal Crops and Diseases and by the Biophysical Laboratory. Cotton improvement and production were studied by three Divisions—Cotton, Rubber, and Other Tropical Plants; Egyptian Cotton Breeding; and Western

Irrigation Agriculture. Fruit crops were investigated by four Divisions—Horticultural Crops and Diseases; Cotton, Rubber, and Other Tropical Plants; Crop Physiology and Breeding; and Economic Botany (blueberry breeding). Many of these duplications occurred among the activities carried on in California. Recent consolidations have eliminated most of this duplication.

The two activities of the Bureau of Plant Industry not included are those of the Division of Forest Pathology and the Division of Blister-Rust Control, both charged with the protection of forest trees and discussed in the chapter on Forest Resources.

Bureau of Entomology and Plant Quarantine: The work of the Bureau of Entomology, created from the previous Division in 1904, was occupied chiefly with the protection of plants from their insect enemies. In 1928, much of the regulatory work of the Bureau of Entomology and of the Bureau of Plant Industry, including that of the former Federal Horticultural Board, was placed in a separate organization named the Plant Quarantine and Control Administration. In 1932 this was designated as the Bureau of Plant Quarantine and, in 1934, merged with the Bureau of Entomology to form the present Bureau of Entomology and Plant Quarantine. The work of the plant-quarantine branch of the Bureau is concerned entirely with the protection of plants against fungous, bacterial, and insect enemies.

Not all entomological activities are concerned with the crop plants treated here. The work of the Division of Forest Insects will be presented in the chapter on Forest Resources, in the volume on Natural Resources, whereas the work of the Division of Bee Culture and that of the Division of Insects Affecting Man and Animals already have been discussed under Animal Industries, bee culture being essentially animal production. Conversely, in the Bureau of Animal Industry, the subdivision on Stock Poisoning by Plants, in the Pathological Division, while dealing entirely with poisonous plants, has been presented in the preceding chapter, under protection of animal industries. The work of such a Division as Foreign Plant Quarantines, in its subdivisions of port inspection and Mexican border inspection, is not concerned with individual crop groups, however, and therefore must be presented under protection of plant industries as a whole.

Bureau of Biological Survey: In this Bureau, a portion of the work of the Division of Food-Habits Research and of the Division of Predatory-Animal and Rodent Control is concerned with the protection of field, pasture, and orchard crops from injurious mammals and birds. The remaining work of these Divisions and that of all other Divisions of the Survey either has been presented under Animal Industries or will appear in the chapter on Animal Resources in the volume on Natural Resources.

The Weather Bureau: The various Branches and Divisions concerned are not so readily correlated with functions and activities. The various Forecast Districts, the Climatological Section Headquarters, the Branch of General Weather Service and Research, and the Fruit-Frost Service, all are concerned with climatology as represented in crop-protection activities.

Other Federal units.—In the Department of the Interior, the Bureau of Reclamation and the Bureau of Indian Affairs have some activities in crop production in which they coöperate with the Department of Agriculture. These relate principally to experiment farms conducted by the Bureau of Plant Industry on Federal reclamation projects and to agricultural operations on the Indian Reservations. The National Park Service of the same Department has much to do with the conservation of wild plants, but this falls properly into the volume on Natural Resources. Under the Taylor Grazing Act the Interior Department has appointed a Director of Grazing in the interest of better pasturage and erosion control on a large portion of the unreserved public domain. The Customs Bureau of the Treasury Department coöperates in maintaining the various plant quarantines at border and port stations in the ways already described for animal quarantines. The Division of Plants (U. S. National Herbarium) of the National Museum of the Smithsonian Institution has extensive though minor relations with the U. S. Department of Agriculture and with the departments of botany of the various State colleges and universities, as well as with private institutions.

State Agencies

In each State two major agencies are concerned extensively with production or protection in plant industries. These are the State



(or State University) College of Agriculture and the State Department of Agriculture.

The college of agriculture comprises various resident-teaching departments, the agricultural experiment station, and the agricultural extension service. The teaching units concerned with plants include agronomy or farm crops, botany, entomology, and horticulture. Some or all of these may be subdivided to form other departments, such as soils, bacteriology, plant pathology, landscape design, etc. These teaching departments have only minor and indirect relations with other official agencies, except as they articulate with the corresponding divisions of the experiment station.

The agricultural experiment station is made up of numerous research divisions, corresponding in general to the teaching departments of the college, but often still further subdivided. The research divisions of the station are likely to have extensive coöperative relations with Federal, State, and local agencies.

The agricultural extension service, conducted coöperatively by the Federal Department of Agriculture and the State agricultural college, is organized on a county basis within each State and therefore has official relations with the county governments as well as with the subject-matter teaching departments of the college and the corresponding divisions of the experiment station.

In California, the plant industries, as noted previously, are exceedingly numerous, diverse, and highly specialized. This is reflected in the organization of the teaching and research divisions of the University of California College of Agriculture and Agricultural Experiment Station. Such of these units as are concerned with plants are more numerous at the California institution, that is, more specialized and subdivided, than in most other States. For instance, what would be the division of horticulture in most State stations is represented at the California Station by the five divisions of pomology, subtropical horticulture, viticulture and fruit products, truck crops, and landscape design.

Among the organization units which have taken part in plant activities are the divisions of agronomy, botany, entomology and parasitology, genetics, irrigation investigations and practice, plant pathology, pomology, subtropical horticulture, truck crops, and viticulture and fruit products, at the California Agricultural Ex-

periment Station, and the department of household science of the University of California.

The State department of agriculture has gradually but definitely evolved from a general agency for education, investigation, and regulation in agriculture, to a fully organized agency primarily and almost wholly devoted to the administration of regulatory activities under State law and its own administrative rules and regulations. Many State departments of agriculture have some investigational activities, either independently or in coöperation with Federal or other State agencies. Usually these are minor studies concerned directly with the methods of enforcing regulatory legislation. The evolution of the State departments as regulatory agencies has been so recent, and so generally without any central coördinating agency comparable to the Federal Office of Experiment Stations in its relation to the State stations, that there is not only great diversity in their organization and scope in the different States but also a steady and confusing shift in the number, naming, and activity of the component units.

In the California State Department of Agriculture, the divisions of entomology and pest control, quarantine administration, and plant industry are active in the work of plant protection. The last-named division comprises five bureaus—field crops, fruit and vegetable standardization, nursery service, shipping-point inspection, and weeds and weed control. The latter has some research activities in coöperation with the State Agricultural Experiment Station.

County and Municipal Agencies

Under the triple coöperation comprising the U. S. Department of Agriculture, the State College of Agriculture, and the Boards of County Commissioners, there is maintained in most counties of the United States an officer of the Agricultural Extension Service known as County Farm Advisor, with one or more assistants. These advisors in many counties have helped to promote experiments and demonstrations in the various plant industries. The same is true of the County Agricultural Commissioners of California, who, under the legislation enacted in 1929, replace the County Horticultural Commissioners and carry even broader functions in respect of plant protection and to a lesser extent plant production. They

have many mandatory relations with the State Department of Agriculture.

Municipal agencies have almost no functions touching the plant industries. In a few cases there are reciprocal relations with rural organizations in connection with fire prevention, including grain-field fires. This is chiefly a California development, where the rainless summers make field fires a serious matter.

OFFICIAL PUBLICATIONS IN PLANT INDUSTRIES

The official literature of the agencies concerned with plant industries falls into seven general classes. These are: (a) annual administrative reports, including proceedings of annual meetings of official organizations; (b) technical or service publications, usually in numbered series, as bulletins, circulars, etc., or in journal or serial form; (c) histories of organizations and activities; (d) annual or less frequent lists of personnel, with official titles and organization assignments; (e) lists of officials, organizations, and institutions concerned with given activities; (f) compilations of laws, regulations, etc., of the United States and of the several States, concerned with a given subject or field of activity; and (g) lists of publications of a given agency, or bibliographies of the literature of a given subject. The last five kinds of publications, (c) to (g), may be issued in one or more of the numbered series or as issues of a journal, as mentioned under (b), or they may be independent or special publications, or they may be found in both classes.

Publications of or about Federal Agencies

Much information about official Federal activities and relations in plant-industry activities may be found in the various series of publications issued by the U. S. Department of Agriculture and its present and former component units. Their annual reports furnish a running picture of developing activities, with frequent references to relations. Special publications and occasional issues in their regular series contain discussions of history, organization, and activities, or lists of personnel, or compilations of laws, and directories of officials, organizations, and institutions. Sometimes private publications present similar data for the Department or for some of its units.

Publications presenting the history and activities of official Federal agencies are important sources of information regarding the relations of these agencies with others in different levels of government. The U. S. Department of Agriculture has published several historical summaries of its organization and activities (22; 28; 50; 51),* since activities in plant industry were begun. It has published also a brief statutory history (7) and compilations of the laws relating to the Department (25:112-31). There likewise are several private publications which discuss the history, organization, and activities of all or some of the units of the Department of Agriculture, including those concerned with plant industries (23; 30; 83; 141; 145).

Another type of publication consists of the (usually) annual lists of the Federal agricultural personnel, with their scientific titles, arranged by the various administrative units and subunits and therefore constituting organization charts as well. (97-177; 100). Other publications contain discussions of the personnel as to numbers, training, and activities (99-1931:190-92).

There may be mentioned also the various lists of publications of the entire Department, for different periods of years. The contents are arranged by series for the Department and also by series as published by the component units previous to June 30, 1913, after which only the Department series were published (29; 32; 33; 135). To these may be added indexes to the annual reports of the Department (125-1) from 1837 to 1893, and to the yearbooks (125-7, 9, and 10) for periods between 1894 and 1910.

The U. S. Department of Agriculture has issued many different series of publications in the more than seventy years of its existence. Among these are annual reports (89), yearbooks (99), reports (98), special reports (127), miscellaneous special reports (128), "miscellaneous reports" (unnumbered) (126), farmers' bulletins (91), Department bulletins (90), technical bulletins (92), circulars (93), Department circulars (94), miscellaneous circulars (95), leaflets (96), miscellaneous publications (97), and, finally, a technical journal, the *Journal of Agricultural Research* (41), and an abstracting journal, the *Experiment Station Record*

* Numbers in parentheses refer to the Literature Cited, at the end of the chapter.

(117). It must be pointed out that the Office of the Secretary (of Agriculture) issued briefly-continued series of circulars and miscellaneous circulars, some years ago, which should not be confused with the departmental series mentioned above.

Much information about early official Federal activities and relations in plant-industry subjects may be found in the annual reports of the Patent Office (134) up to 1862 and in the annual reports of the U. S. Department of Agriculture beginning with that year (89). Previous to the creation of the Bureau of Plant Industry in 1901, there were several Divisions in the Federal Department of Agriculture which were concerned with plant production or protection. Some of these, with the dates of their establishment, were the Division of Propagating Garden, 1862; Chemistry, 1862; Entomology, 1863; Botany, 1868; Pomology, 1886; Vegetable Physiology and Pathology, 1887; Agricultural Soils, 1894; Agrostology, 1895; and Seed and Plant Introduction, 1900. The annual reports of these various Divisions are found in the series of volumes comprising the annual reports of the Department of Agriculture (89). These reports are found only in this annual volume up to about 1889, when the Commissioner of the Department became Secretary, with a place in the President's Cabinet. From about that year, though the date varied somewhat for the different Divisions, their annual reports were reprinted and distributed also as separate pamphlets. This continued up to the time when they became independent bureaus or component parts thereof, mostly soon after 1900. Annual reports of the Bureau were issued in the same way for many years.

The Bureau of Plant Industry, created in 1901, has published annual reports (120) regularly since that year. It issued a series of bulletins (121) and a series of circulars (122) until June 30, 1913, when all Bureau series were discontinued and Departmental series begun. Since then it has issued directories of its field activities, and major field personnel, at intervals, in one or another of the Departmental series (97—64 and 129). A general statement of its coöperative activities was published occasionally (120—1905:67 and 1907:260—61).

The Bureau of Entomology, established in 1904 (now Entomology and Plant Quarantine), has issued annual reports (107), bul-

letins, (old series [108], new series [109], and technical series [110]), circulars, second series (111), and seven volumes of a technical journal, *Insect Life*, besides five reports of the U. S. Entomological Commission. It also has issued directories of its field activities (97—47, 83, and 220). The Bureau of Plant Quarantine, established as the Plant Quarantine and Control Administration in 1928 and as the Bureau of Plant Quarantine in 1932, has issued annual reports from 1929 to 1933 (124).

The Bureau of Chemistry (now Chemistry and Soils) has issued annual reports (104), bulletins (105), and circulars (106).

The Office of Experiment Stations has issued annual reports (113), bulletins (114), miscellaneous bulletins (115), circulars (116), an abstracting and editorial journal, the *Experiment Station Record* (117), which formerly contained articles of semi-administrative nature, and a series of reprints from other series, which were issued under document numbers.

The Bureau of Biological Survey has issued annual reports (101), bulletins (102), circulars (103), and a numbered technical series called *North American Fauna*, besides directories of its field activities (97—49). All of these various units also have issued large numbers of publications in one or another of the regular series of the Department.

Service Monographs of the Institute for Government Research contain general administrative material on each of the important Federal units concerned with plant industries. Those of especial importance are as follows: Bureau of Biological Survey (38—54); Bureau of Entomology (38—60); Office of Experiment Stations (38—32); Bureau of Plant Industry (38—47); Bureau of Plant Quarantine (38—59).

Publications of or about State Agencies

Official documents relating to the administration of State agencies, including their histories, organization, activities, budgets, publications, personnel, and the laws under which they operate, arise from two major sources, the Federal government and the State institutions themselves. The U. S. Department of Agriculture, for instance, has published annually for many years a comprehensive list (118) of the personnel of the workers in classified subjects

pertaining to agriculture in all the State colleges of agriculture, which includes the staffs of the agricultural experiment stations and the extension services. The Department also has published consecutive lists of the bulletins and technical bulletins of the State agricultural experiment stations, covering longer or shorter periods of time. The first such list (90—1199) covered the period from the founding of the stations (mostly 1887 and thereafter) to the end of 1920. Biennial lists have been issued since (90—1199, Suppl. 1, 2, and 3; 97—65, 128, 181, and 232).

The State agricultural experiment stations, the agricultural extension services, and departments of agriculture all publish annual reports. In some States these are published as numbers of a regular bulletin series, whereas in others they are not so included. In some States, as in California, the State department of agriculture publishes a journal and the annual report comprises the final issue of each year (12). The experiment stations also issue various series of technical or popular matter, such as bulletins, technical bulletins, circulars, etc., which occasionally contain administrative documents. Some stations, as in California (31), publish serial journals also. Likewise some State departments of agriculture publish bulletins in numbered series.

The publications listed in the Literature Cited at the end of this chapter which have been cited in this section on Introduction are Nos. 7, 12, 22, 23, 25, 28, 29, 30, 31, 32, 33, 38, 41, 50, 51, 83, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 113, 114, 115, 116, 117, 118, 120, 121, 122, 124, 125, 126, 127, 128, 134, 135, 141, and 145.

2. PLANT PRODUCTION AND PROTECTION

IT IS MOST CONVENIENT and logical to discuss the relationships of official agencies in the various plant industries under groups of crops related in commercial use, such as cereals, fibers, forages, fruits, saccharines, vegetables, etc. The major Divisions of the Federal Bureau of Plant Industry are organized on this subject-matter basis, as also, to a considerable extent, are units of the various State agricultural experiment stations. There are certain fundamental aspects of plant industries, however, which do not lend themselves to separation along crop lines but are best treated in a

general discussion. Some of these aspects belong to plant production, some to plant protection.

PLANT PRODUCTION

Some of the general activities in plant production, not readily separated by specific plant groups, are Botanical taxonomy and classification, Plant introduction and distribution, Seed investigations, Irradiation of seeds and plants, and Tillage and rotation studies (both dry-land and irrigated). Some official interrelations have developed in each of these general fields and these are presented herewith, rather than under crop groups.

Botanical Taxonomy and Classification

All agriculture is dependent upon the foundation sciences. Botany as a fundamental science is concerned with determining the systematic relationships of plants, classifying them into related groups, describing them so that they may be recognized when in hand, and bestowing scientific names upon those feral species and varieties not previously known to science. Systematic botany serves plant industry in at least four ways. First, by furnishing this fundamental information regarding the wild plants of the world. Second, by identifying and furnishing ecological information on newly introduced plants which show symptoms of becoming weed pests either by direct competition or as the hosts of destructive insects or diseases. Third, through identifying the wild plants which furnish the regular or emergency feed or browse of domestic animals, game animals and birds, and other agriculturally important birds and animals, either beneficial or harmful. Fourth, by describing and classifying the numerous varieties of cultivated plants, and the fungi attacking them. This latter service is most commonly performed by specialists in applied botany, such as agronomists, horticulturists, mycologists, etc.

The importance to agriculture of a knowledge of the wild relatives of cultivated plants cannot be overestimated. Such a knowledge may serve any or all of several different and often urgent needs. Among these are the geographic sources for other plants valuable for domestication, or for hybridizing with cultivated plants to give them greater vigor and resistance to diseases, insect

pests, or climatic factors. This knowledge also may reveal the location of pests which affect cultivated crops, or furnish sources of parasitized individuals of such pests from which useful parasites may be bred. The distribution of wild relatives may afford clues to the possible distribution of the related crop plants.

In the United States the Federal agency for maintaining collections of dried specimens of wild plants is the National Herbarium of the United States National Museum, which is a major unit of the Smithsonian Institution at Washington, D. C. Similar though smaller collections are found at each of the forty-five State universities, at the more than twenty separate agricultural colleges, and at a few State or city museums, as well as at some of the numerous State teachers' colleges, junior colleges, etc. Large collections are maintained by many private universities and by a few privately endowed and supported botanical gardens, academies of science, and museums.

The great National Herbarium at Washington, D. C., was founded by the Smithsonian Institution in the course of development of its scientific program. In 1868 the herbarium was transferred to the U. S. Department of Agriculture. In the appropriation bill for that year, provision was made for the appointment of a botanist in the Department to take charge of the herbarium. Later the National Herbarium was returned to the custody of the National Museum of the Smithsonian Institution, where the other scientific and cultural collections of the Federal Government are deposited. The Department botanist long was Curator of the National Herbarium and the Department furnishes other personnel also and contributes an immense number of botanical specimens each year. Quite recently the independent botanical collections of the Federal Forest Service have been incorporated in the National Herbarium.

The U. S. Department of Agriculture maintains an extensive herbarium of specimens of cultivated plants, of plants infected by fungi and bacteria, and recently of all useful plants.

There is a series of interrelations between these various botanical depositaries throughout the world. No distinction is made between officially supported and privately supported institutions in these relations. Members of their staffs collect plants in duplicated sets, varying in number from ten to as many as fifty or more.

These are exchanged with other institutions for similar sets prepared under their auspices. In this way plants collected in far corners of the world come to a resting place in many American institutions. In the second place, specialists employed by, or temporarily located at, any given institution may borrow material in their field from other institutions, without charge, and retain it for study as long as desired. In fact, it is the common practice for institutions to send material of their difficult groups for identification by specialists at other institutions. In the third place, staff specialists from one institution are gladly welcomed at any other depositary and afforded every facility for making such studies as they wish.

The herbarium of the Department of Botany of the University of California is the recognized Pacific Coast depositary for duplicate sets of plants distributed by the United States National Herbarium at Washington, D. C. The University herbarium is widely used by those concerned with weeds, crop plants, grazing and browse plants, and other plant groups of California and of the Western Coast in general.

More and more the agronomists, horticulturists, and foresters, as well as the pathologists, entomologists, physiologists, and ecologists concerned with the various groups of crop plants, make use of the facilities afforded by the great herbariums of the world, in the various ways mentioned above. Numerous instances of such cooperation may be noted in botanical publications, where acknowledgments are given in text or footnote, or in plant-industry or animal-industry papers, where specialists other than the authors contribute paragraphs or sections identifying or describing wild relatives of some cultivated crop, or some newly introduced weed of agriculture, or some plant discovered to be poisonous or beneficial to animals.

Plant Introduction and Distribution

The search for new or little-known wild and cultivated plants goes on throughout the world. Official and private institutions, and even private individuals, take part in the exploration and in the testing of the resulting material for adaptation and commercial value. All known means of travel and transportation are employed,

including airplane, automobile, ship, boat, canoe, caravan, pack train, and safari.

The idea and the practice are by no means new. Throughout all ages, travelers, explorers, and invading armies have gathered useful plants and animals for the countries from which they came. With the development of oceanic exploration, and especially with the quest of a sea route to the Orient, which resulted in the discovery of the Americas, the process was greatly augmented. All maritime nations attached plant collectors to their expeditions, usually in the person of the medical officer, and a great international exchange of plants took place, largely through the various botanical and horticultural gardens and societies. In recent decades, two nations having enormous and diverse areas of land, with some large tracts arid or semiarid in character, have undertaken very extensive official and some private exploration for new plants and plant industries. These two are the United States of America and the Russian Union of Socialized Soviet Republics.

In the United States, the Federal government has fostered or taken part in plant introductions for more than 150 years. Franklin and others sent seeds and cuttings to the homeland while representing it on diplomatic missions abroad. From 1804 to 1806 the official Lewis and Clark Expedition was traversing the then unknown Far Northwest to the mouth of the Columbia River. By the irony of fate, its plant collections lay forgotten in a Philadelphia basement for more than a century, in which time the plants had mostly become known to science through other expeditions and collectors. Later, as pointed out in the introduction to this chapter, naval and consular officers were directed to obtain seeds and plants abroad, the distribution finally being undertaken by the Patent Office of the State Department.

After the creation of the U. S. Department of Agriculture in 1862, it was instrumental in making contacts abroad and obtaining and distributing seeds of useful plants, especially sugar beets and saccharine sorghums. In about 1900, an Office of Foreign Seed and Plant Introduction was organized in the Department and explorers were sent to the Near East for cereals, forages, and other plants likely to be useful to the expanding agriculture in our semi-arid West.

Some of the State universities and State agricultural colleges also made introductions of crop plants direct from foreign lands, either through correspondence with colleagues abroad, or through visits of staff members to such countries as students or expert advisors, or merely as travelers. In the same way various privately endowed botanical gardens obtained seeds and plants from similar institutions abroad.

The Division of Foreign Plant Introduction of the U. S. Bureau of Plant Industry carries on a wide range of activities in obtaining, from all corners of the world, the seeds and plants of wild and cultivated species of possible value in some part of the United States or its widely scattered possessions. This program of exploration and introduction is accomplished in part by its own staff, in part by staff members from other technical divisions of the Bureau, and in part through its effective contacts with numerous explorers, expeditions, consular officers, administrative officials, research specialists, missionaries, and other interested persons in all parts of the world. To care for this material properly after its receipt, to determine its possible adaptation to environmental conditions in this country, and to increase desirable material for distribution, the Division maintains field stations or introduction gardens in various parts of the country. It also coöperates with other Divisions of the Bureau, with State experiment stations, and with private plant growers, in furnishing them its material for tests.

In California, the Division maintains the large and well equipped U. S. Plant Introduction Garden at Chico, which is fairly typical of its field activities. The garden was established there in 1904, when 80 acres of land were made available by the Plant Garden Company, through the director of the California Agricultural Experiment Station. The Plant Garden Company was a body incorporated on August 3, 1904, to acquire land and to donate the same to public agencies for a plant-introduction garden. It raised funds by public subscription and purchased the eighty-acre tract. By the expressed desire of the then Secretary of Agriculture, this land was conveyed by deed in trust to the then director of the California Experiment Station and his successors in office. This coöperative arrangement was continued until 1921, in which year the Plant Garden Company and the Experiment Station

jointly deeded the land and certain buildings to the U. S. Department of Agriculture. Provision was made in the annual appropriation act for the Department, in that year, for the acceptance of the land and for the purchase of 130 acres additional. Besides this land purchase, the Division of Foreign Plant Introduction has expended nearly \$42,000, since 1905, in providing buildings and equipment.

Available material is furnished to the interested divisions of the California Agricultural Experiment Station, on request, and to private growers who are equipped to make adequate tests. Recently the Plant Introduction Garden has supplied the Division of Pomology, at the California Station, with all available collections of almond and apricot seeds. Distribution of material from this Garden is enormously wider, however, than the State of California, or even the Pacific Coast. The recent budget for the work of propagating, testing, and distributing new plant introductions has been about \$30,000 annually.

Most of the other units in the Bureau of Plant Industry work with and through the Division of Foreign Plant Introduction when they wish foreign material. Not infrequently representatives of such divisions as Cereal Crops, Forage Crops, Horticultural Crops, Sugar Plants, etc., go abroad as special explorers of the Plant-Introduction Division.

Some independent work in plant introduction has been done by the (former) Division of Cotton, Rubber, and Other Tropical Plants of the U. S. Bureau of Plant Industry, which maintained three acclimatization gardens or field stations in California, as well as one at Sacaton, Arizona. The three California Stations were the U. S. Acclimatization Garden on the Fort Yuma Indian Reservation at Bard, in the Colorado Valley, near Yuma, Arizona; the U. S. San Diego Acclimatization Garden at Torrey Pines, near La Jolla; and the U. S. Cotton Field Station at Shafter in the San Joaquin Valley. Of the four, the first and fourth (at Bard and Sacaton) were provided by the Bureau of Indian Affairs, Department of the Interior, the second by the city of San Diego, and the third (at Shafter) by the Board of Supervisors of Kern County. The introductions, in addition to cottons, rubber-producing plants, and their relatives, were principally in the field of tropical and sub-tropical fruits. A fuller discussion of these stations will be given

in connection with the presentation of the work on cotton and rubber, beginning on page 619.

Seed Investigations

The testing of the quality of seeds was not begun until many years after the creation of the U. S. Department of Agriculture, although the collection and distribution of seeds had been begun by the Patent Office in 1839. Seed testing for germination and purity was performed as an interdivisional service by the Division of Botany at intervals over many years. The development of market gardening resulted in a rapidly expanding commercial trade in vegetable and flower seeds. Increasing complaints of lack of purity and vitality in many kinds of seeds caused the Congress to authorize the Secretary of Agriculture in 1898 to purchase samples of seeds in the open market, have them tested in the Division of Botany, and, at his discretion, publish the names of the seed firms wherever the seeds were found to be below standard quality. This authorization has been continued and some additions have been made in later years. In 1904 the wording of the act was made mandatory rather than permissive. The coöperation of other Divisions of the Bureau of Plant Industry and of the State agricultural experiment stations was had in obtaining samples of seeds offered for sale in commercial channels. The Seed Laboratory became an independent unit of the Bureau of Plant Industry in 1901. Later it was called the Division of Seed Investigations.

As the system of State agricultural experiment stations developed, either these or the previously existing State departments of agriculture were invested by the States with authority to test commercial seeds for purity and vitality. These agencies rendered the same interunit services as were performed in the Federal organization. As the Federal work expanded, it became desirable to have seed-testing laboratories located at different points over the country in order to save time in shipment of material and in return of the desired information. Several such laboratories have been established in coöperation with State agencies. In recent years, four have been maintained in the central and western parts of the country. They are in coöperation with the Agricultural Experiment Stations at Purdue University, LaFayette, Indiana, at

the University of Missouri, Columbia, and at Oregon Agricultural College, Corvallis, and with the California State Department of Agriculture at Sacramento.

The California laboratory was established in 1911, in the Bureau of Plant Industry of the State Department of Agriculture, under a coöperative agreement signed by the Federal Bureau of Plant Industry and the State Department. The Federal agency furnishes some apparatus and pays somewhat more than one-fourth of the total salaries. The State agency pays the remainder of the salaries and provides the necessary laboratory room, equipment, heat, light, and clerical and janitor service. The State agrees that this laboratory shall make all tests of seeds entering the United States through California ports, under the terms of the Seed Import Act discussed below. The Oregon laboratory performs the same service with regard to foreign seeds arriving at the ports of Seattle and Portland.

In addition to these coöperative field laboratories, the Division of Seed Investigations maintains a large force of collaborators throughout the country to aid in the collection of samples and in similar work. They average better than one collaborator per State. Many of them are representatives of the State stations, serving without pay or with merely nominal compensation.

The official seed-testing specialists of the Federal Division and the State agricultural experiment stations have formed a national organization, the Association of Official Seed Analysts of North America, which investigates methods, discusses procedures, and adopts rules for seed testing (94—406).

An important recent piece of Federal seed legislation involving extensive official relations between the U. S. Departments of Agriculture and the Treasury is the Seed Import Act of August 24, 1912 (37 U. S. Stat. L, 506), with subsequent amendments. This act had two somewhat distinct purposes. The first intent was to prevent the importation of agricultural seeds which were adulterated or unfit for seeding purposes, and the Secretaries of Agriculture and the Treasury were directed to make such rules and regulations as would prevent such importations. The second intent was to prevent the importation and sale of seeds of alfalfa and red clover of geographic strains not adapted to culture in the

United States, even though such seeds are pure and sound. To this end provision was made for the artificial coloring of such importations to show country of origin. Again the Secretaries of Agriculture and the Treasury were required to prescribe jointly such rules and regulations as would make the law effective.

Irradiation of Seeds and Plants

The chief coöperative activity in this field is sponsored by the National Research Council, a Federal agency established in 1916 at the request of the President of the United States, under the charter of the National Academy of Sciences, which in turn, by act of Congress, is an official advisory body to the Federal Government. Under the Council's Division of Biology and Agriculture there was created in 1929 a Committee on the Effects of Radiation on Living Organisms, which since has been instrumental in obtaining grants of funds, apparatus, and radium for these researches, and making them available for use by qualified researchers in many institutions, including several State universities. The research has covered both plants and animals, and many plants other than those of immediate value in agriculture.

Three of the projects cover research in important crop plants. At the University of Missouri, the Agronomy Division in the Experiment Station is conducting research into the genetics and breeding of cereal crops in coöperation with the Division of Cereal Crops and Diseases of the Federal Bureau of Plant Industry. Grants for the study of radiation effects have been allocated to this project by the National Research Council and several important contributions have been published (62—1930:52 and 1931:39). Grants have been made also to the Divisions of Plant Breeding and Botany at the Cornell Agricultural Experiment Station for studies of the effects of irradiation on the genetics of maize, a project also in coöperation with the Federal Division named above (62—1932:47). Grants have been made to the Department of Botany of the University of California for similar studies of the genetics of the tobacco plant and several published contributions have resulted (62—1930:51-52 and 1931:38). A volume summarizing the critical knowledge in this field is projected by the above-named committee, under the authorship of certain of the endowed specialists.

Rotation and Tillage Studies

Plants are sensitive to many environmental circumstances, including the condition of the soil and the nature of the preceding crop or crops. This is especially true in areas of deficient precipitation, such as the western half of the United States. It was natural, therefore, that tillage and rotation experiments should have been begun in the West soon after official agencies established stations and substations in such areas.

Rotation experiments include not only variations in the order in which different crops occupy the same land and variations in the number of successive seasons during which any one crop may occupy it, but also the substitution of bare fallow for crop at varying intervals. The purpose of the fallow is to permit the accumulation of larger quantities of precipitation in the soil, and this, in turn, requires research on rate and depth of percolation under varying conditions. Tillage experiments include the effects of surface and subsoil tillage with different types of implements, at different seasons of the year, at different depths, at varying intervals of time, and on different soils, as measured by the response of different crops. This work too is correlated with the rate and amount of percolation of precipitation. Most of these experiments are conducted also under conditions of irrigation, in dry-land areas, which involves study of the effects of different methods, times, frequencies, and quantities of water application.

The principal crops involved in rotation and tillage experiments are the cereals, the dominant crops of dry-land areas, but forage grasses and legumes also are commonly included. To a more limited extent, potato and other truck crops, as well as sugar beet, are employed in rotations.

In the Federal Bureau of Plant Industry (120), no less than three units have had an active part in rotation and tillage experiments, independent and coöperative, while a fourth has had a minor part.

Dry-land experiments.—In 1903, the Division of Cereal Crops and Diseases (then Office of Grain Investigations and later Cereal Investigations) began the establishment of field experiments in different sections of the dry-land West. A few were on independ-

ent stations, most were coöperative experiments on State substations, and some were on stations operated by the other Plant Industry units named below. While the primary object was cereal experiments, these included less or more extensive rotation and tillage experiments in the Far West where the Division of Dry-Land Agriculture did not operate.

The three major coöperative substations of this area were the Nephi Substation in Utah, the Sherman County Branch Station at Moro, Oregon, and the Adams County Branch Station at Lind, Washington. So well correlated were the studies that it was possible to publish the results affecting wheat from all three in a single bulletin (90—1173), with joint authorship and a box statement of coöperation. Some preliminary results were published in the *Circular* series (122) of the Bureau of Plant Industry and more complete results later by both agencies. For the Nephi (Utah) Substation the results of tillage and rotation studies from 1908 to 1912 were published by the Federal Department (90—157) in 1915, by the State station (136—175 and 222) in 1920 for the sixteen years to 1919, and in 1930 for a full quarter century. For the Sherman County Branch Station, in Oregon, some data with reference to fallow rotation were published by the Federal agency (90—498) in 1917 and by the State station (78—119, 144, and 190) in 1914, 1917, and 1922, with a full discussion of rotations (78—209) in 1924. Less extensive coöperation with the State at the Harney Valley Branch Station at Burns, from 1911 to 1920, was published by the State (78—119 and 150) in 1914 and 1918. The principles of summer-fallow tillage at the Adams Branch Station, Washington, were published under joint authorship by the State station (142—183) in 1924, covering coöperation that ended in 1920.

In 1905 there was created a Division (then Office) of Dry-Land Agriculture Investigations, which gradually developed an extensive series of dry-land field stations on the Great Plains. It had to do primarily with crop rotations and tillage methods, the former including fallow and the plowing in of green-manure crops. Because of the semiarid climate, much attention was given to the conditions influencing the penetration and storage of precipitation. The Federal Weather Bureau furnished the necessary mete-

orological instruments and record blanks for all stations and the Plant Industry Division of Biophysical Investigations collaborated in the tabulation and computation of the records.

By 1912 the stations numbered fourteen and by 1920 there had been twenty-four stations established. Through elimination the total had been reduced to nineteen. One new coöperative station recently was established in Oregon, the only one outside the Great Plains. In Colorado, the station was established on a tract given to the State for forestry purposes, and only nominal coöperation occurred. In Kansas, Montana, Nebraska, and North Dakota, the strictly dry-land stations were parts of previously or newly established substations of the State stations. In New Mexico, Oklahoma, South Dakota, and Texas, independent field stations were established on land made available through local commercial effort. In New Mexico and Oklahoma, however, the work eventually became coöperative with the States. In Wyoming, the work was conducted on tracts made available through the State Board of Farm Commissioners and later transferred to the Experiment Station. The tract at Archer, Wyoming, as well as that at Amarillo, Texas, was operated by the Office of Cereal Investigations. In three cases, the work was done on nonirrigated portions of later-described irrigation stations of the Plant Industry Office of Western Irrigation Agriculture, located on the Federal reclamation projects at Huntley, Montana, Scotts Bluff, Nebraska, and Belle Fourche, South Dakota. In Montana and Nebraska, these irrigated stations were conducted in coöperation with the State.

In 1915, the results obtained from study of the relation of cultural methods to crop production, on the fourteen dry-land stations established by 1912, were published, by the Federal agency, for spring wheat, for oats, for corn, and for barley (90—214, 218, 219, and 222), and for corn, kafir, and milo in the southern section (90—242). So also was published the effect of plowing grain stubble at different times in eastern Colorado (90—253), while subsoiling results (41—14:481) were presented in 1918. A summary of crop-production results concluded the series (90—268). Two State stations published some data at about the same time, Montana reporting on both rotations and cropping methods at the Judith Basin Substation at Moccasin and the Huntley reclamation project

from 1908 onward (60—116) in 1917, and North Dakota in 1915 on dry-farming investigations in its own western parts (74—110).

From 1921 onward both the Federal agency and the individual State stations began publishing the accumulating results, most abundantly about 1925. A third series of cumulations was beginning to appear in 1932 and 1933. Publications from both sources showed the coöperative relations by footnote or textual statements and in many cases by Federal-State joint authorship also. Certain of the Federal Department bulletins showed the coöperation in a box statement on the cover.

For the Akron Field Station in Colorado, in 1925, the Federal agency published (90—1287) the results of fifteen years of dry-land experimentation, 1908—22. For the Garden City Branch Station, in 1927 and 1932, under joint authorship, the Kansas Station published results (42—239 and 262). In 1921, Montana published on fallowing experiments at the Huntley reclamation project station (60—142); in 1927, on cultivation methods at the Judith Basin Substation (60—205); and in 1926 on wheat production at the Northern Montana Branch Station (60—197). On the other hand, in 1925, the Federal Department published on fallowing studies in Montana (90—1310), and in 1933 on its rotation and tillage studies at Huntley (92—353).

In 1923, Nebraska published the results of coöperative dry-farming studies on the Scotts Bluff Substation (63—192), and under joint authorship, in the same year, the results of sixteen years of coöperative investigation at the North Platte Substation (63—193), with another presentation of cumulated results (63—279) ten years later. In New Mexico the work at the Tucumcari Field Station was published by the State (69—130) in 1922 and again (69—176) in 1929. In 1921 the fifteen years of coöperative results from the Edgeley Substation in North Dakota were published by the Federal Department (90—991), and again in 1925 the Department summarized the results (90—1293) of rotation and tillage experiments conducted from 1905 onward at several North Dakota substations. In 1925 also, it summarized (90—1301) the mostly independent studies on the Northern Great Plains Field Station at Mandan, North Dakota, for 1913 to 1923, and presented the annual data (90—1337) for 1923. The results obtained in South

Dakota at the independent Ardmore Field Station were published (92—17) by the Federal agency in 1927, and in 1934 those from coöperation with the Division of Western Irrigation Agriculture at the Belle Fourche reclamation project (92—454). In 1925, the Federal agency published results (90—1306) from the coöperative Sheridan Field Station in Wyoming, while in 1927 the State Station presented the results (148—150) for 1918 to 1926. Results obtained coöperatively at the Cheyenne Field Station were summarized by the Federal agency (90—1315) in 1925, and published by the State Station, with reference to effects on wheat production (148—151, 161, and 173), in 1922, 1929, and 1930.

Irrigated field stations.—The Division (formerly Office) of Western Irrigation Agriculture in the Bureau of Plant Industry was created in 1910, to conduct experiments with crops and cropping methods and the control of injurious alkalis, for the benefit of settlers on the reclamation projects developed by the Bureau of Reclamation of the Department of the Interior. The Bureau of Reclamation makes available to the Bureau of Plant Industry sufficient land area for the experiments, and supplies the necessary irrigation water. Plant Industry provides the buildings, ditches, implements, labor, and all other expenses for the experimental areas. Particular crop experiments may be conducted in coöperation with other Divisions of the Plant Industry Bureau or with other Bureaus, such as Chemistry and Soils. Livestock experiments usually are coöperative with the Federal Bureaus of Animal Industry and/or Dairy Industry, and sometimes also with the Animal Husbandry Division of the State Agricultural Experiment Station.

The field stations are as follows: Yuma Field Station, Bard, California; Huntley Field Station, Huntley, Montana, in coöperation with the State Station and the Federal Bureaus of Animal Industry and Dairy Industry; Scotts Bluff Field Station, Mitchell, Nebraska, in coöperation with the Nebraska Station; the Newlands Field Station, Fallon, Nevada, where the livestock experiments are coöperative with the State Station; the Umatilla Field Station, Hermiston, Oregon; the Belle Fourche Field Station, Newell, South Dakota, where the livestock and pasturing studies are coöperative with the Federal Bureau of Animal Industry; the San

Antonio Field Station, San Antonio, Texas; and the Washington Irrigation Branch Station at Prosser, not on a Federal reclamation project, where the Federal Division coöperates with the State Station in special studies of the penetration and movement of water and soluble salts and their effects on crops.

Most of the results obtained on these field stations have been published as unnumbered pamphlets of the Division of Western Irrigation Agriculture, each presenting the results at one station for one year. A few have appeared in Departmental and State Station series. The summarized data on irrigated rotations at the Huntley, Montana, Field Station from 1912 to 1926 were published (92—144) in 1929 and the complete data, including rotations, for 1927—30 were issued (92—353) in 1933, with the three-way Federal-State coöperation shown in both cases, and the last paper authored by three Federal Divisions. In the same way, the irrigated rotations conducted at the Scotts Bluff Field Station in Nebraska were summarized and published (92—2) in 1927, with the three-way Federal-State coöperation shown by footnote statement. A summarized discussion of results from 1922 to 1925 was published also (93—5). The State previously had published (63—190) on the irrigated rotations in 1923, with a box acknowledgment of coöperation on the inside front cover. Many of the data accumulated at the Newlands Field Station in Nevada have been published by the State, the first being a summary (66—120) for the years from its opening in 1907 to 1929, with Census Bureau economic data for 1912 to 1929, and the others (66—123 and 127) being supplements for 1930 and 1931. A general presentation of the work at the Belle Fourche Field Station in South Dakota, covering results from 1907 and detailed data from 1926 to 1932, was published (92—454) in 1934, with authors from two Divisions of Plant Industry and one Division in Chemistry and Soils.

Coöperative studies of the alkali tolerance of plants were published (3—11) by the Arizona Station in 1926, under authorship of a joint representative of the Station and the Federal Division of Western Irrigation Agriculture.

Agricultural extension activities with farmers on Federal reclamation projects were conducted by an Office of Demonstrations on Reclamation Projects in the Bureau of Plant Industry from

1914 to 1924, when the work was transferred to the Agricultural Extension Service.

The publications listed in the Literature Cited at the end of this chapter which have been cited in this subsection on Plant Production in the section on Plant Production and Protection are Nos. 3, 41, 42, 60, 62, 63, 66, 69, 74, 78, 90, 92, 93, 94, 120, 122, 136, 142, and 148.

GENERAL PLANT PROTECTION

There are certain phases of the protection of the plant industries which apply to plants in general rather than to any single group of crop plants such as cereals or forages. The annual coöperative survey of the distribution and severity of fungus and insect pests, and likewise certain lines of quarantine work, are examples of general protection. The damage done by certain groups of animals, such as rodents and some birds, is not confined to a single group of crops. The control of weeds is a general activity, because many weeds compete against whatsoever crop occupies the infested field. With the exception of special weather forecasts, such as those for citrus growers, most of what the Weather Bureau does in protection of the agricultural industries is general in nature.

From Fungus and Insect Pests

The most important general activities in the protection of plant industries from fungus and insect pests are the annual surveys of fungus diseases and of insect injuries, and the maintenance of plant and insect quarantines.

Classification of fungi and insects.—Studies in the morphology and taxonomy of fungi and insects are as necessary as those of higher plants, already discussed. Newly discovered or introduced forms may be either harmful or beneficial, and should be promptly identified. Such identification not only requires the coöperation of institutions having specialists but also presupposes available classifications of known species. Where these are lacking, official agencies often must provide them in order to meet their responsibilities. This requires the coöperation of institutions having collections of material.

A recent example in the field of insect taxonomy is afforded by a study of the classification of the North American Agallian leaf

hoppers (92—372), conducted by the Federal Bureau of Entomology on material obtained in part from several State universities and agricultural colleges.

Bibliographies of fungus-disease literature.—Bibliographic contributions usually emanate from Federal agencies. Occasionally State agencies undertake such general service. In 1894, the Connecticut (New Haven) Agricultural Experiment Station issued a provisional bibliography (20—118) of works published by both Federal and State agricultural agencies on the fungus and bacterial diseases of economic plants.

The Federal Department of Agriculture has compiled two such author and subject-matter indexes of plant-pathology literature. The first contained papers published in the Department itself (119—8) to the end of 1924. The second contained the papers published by the State stations (119—16) to the end of 1927.

Biocides (fungicides, insecticides).—The preparation and testing of biocides has been a coöperative activity of plant pathologists and entomologists with botanists, chemists, and agricultural engineers, in both Federal and State institutions, for many years. In the testing and application of biocides in the field and orchard, and on the range, the coöperation of agronomists and horticulturists, as well as wild-life experts, has been had. This subject has been discussed in full in chapter 4, on Agricultural Chemistry. Two recent studies, not included there, will be mentioned here. Critical studies of pyrethrum as an insecticide were made by the Federal Bureau of Chemistry and Soils and the Food and Drug Administration (92—198). The effect of seed treatments in reducing losses from plant diseases was discussed jointly by the Federal Bureau of Plant Industry and the Extension Service (97—94).

Insects affecting many kinds of plants.—Many insects affect plants of more than one group and therefore must be treated under the general topic of plant protection. An example is the bud moth, studied coöperatively by the U. S. Bureau of Entomology and the Connecticut Agricultural Experiment Station. It affects apples and many other fruits, as well as numerous kinds of trees and shrubs (90—1273). While nematodes are not insects but microscopic worms, they attack many kinds of plants and a study of the stem nematode on wild hosts was made coöperatively by the

Federal Bureau of Plant Industry and the Oregon Agricultural Experiment Station (90—1229) and published in 1933.

Annual survey of fungus diseases and insect pests.—Ever since about 1919 the Division of Mycology and Plant Disease Survey of the Federal Bureau of Plant Industry has been engaged in making an annual survey of the geographic distribution and the estimated abundance or severity of the various fungus diseases which attack crop plants, including forest and ornamental trees. The actual work of gathering the information is accomplished through a large corps of collaborators comprising at least one qualified pathologist at each State college of agriculture, assisted by other State and Federal and some private personnel. These collaborators hold a Federal appointment which gives them the franking privilege for the transmission of their reports, but are not paid for their services. The results are interpreted and summarized at the end of the year by a competent committee and then are issued as comprehensive mimeographed reports (123—86) in which the diseases are arranged according to the crop they affect. In recent years there has been prepared also an annual estimate of the actual money loss occasioned by each of the more important of the diseases (123—87). In 1926 there was published a check list of the diseases of economic plants in the United States (90—1366), based on these and other sources.

In the Bureau of Entomology a similar activity was organized in 1921 by the Division of Insect Pest Survey. It likewise depends on a large corps of collaborators, mostly State and Federal personnel. It differs from the Plant Disease Survey in summarizing and issuing its information monthly as well as annually (112—14). Both units identify specimens of fungi and insects sent by collaborators.

Quarantine agencies.—*Federal agencies:* A Federal Horticultural Board was created by an act of Congress of August 20, 1912, usually known as the Plant Quarantine Act. This Board was charged with the administration of the act and it was mandatory that the Bureaus of Entomology and Plant Industry and the Forest Service should be represented in its membership of five persons. On July 1, 1928, the Board was abolished, a Plant Quarantine and Control Administration was created, and the administration of the Plant Quarantine Act and many other pieces of protective

legislation was transferred to the new agency. On July 1, 1932, the name was changed to Bureau of Plant Quarantine. The various Divisions of the Bureaus of Entomology and Plant Industry coöperated informally in many ways. In 1934, the two Bureaus of Entomology and Plant Quarantine were merged into a single Bureau of Entomology and Plant Quarantine.

There is coöperation with the Customs Bureau of the Treasury Department at points where port and border inspection are maintained, as described later, and with the officials of the Post Office Department at these points and elsewhere. The Department of State coöperates in arrangements for export inspection of plants by foreign governments. There also is full coöperation with State agencies.

State agencies: The State agency charged with the enforcement of State quarantine laws, and with coöperation in the enforcement of Federal quarantine laws, usually is a division or bureau of the State department of agriculture. In California, the authority lies in two divisions, namely, entomology and pest control, and the quarantine administration. There is much informal coöperation with entomologists and plant-industry specialists in other divisions of the State department and also in the University of California College of Agriculture. Under California law the county agricultural commissioners work with State officials in all such matters. There is full coöperation between State and Federal agencies.

Quarantine acts.—The three general acts under which there is a safeguarding of agronomic, horticultural, and forest crops, are the Insect Pest Act, the Plant Quarantine Act, and the act providing for terminal inspection of postal shipments.

The Insect Pest Act: This act, of March 3, 1905 (33 U. S. Stat. L, 1269) represents the earliest Federal legislation against plant pests. It prohibits the importation and interstate transportation of insects injurious to plants, and declares them unmailable. Such insects, when needed for scientific purposes, may be transported under proper Federal regulation.

The Plant Quarantine Act of 1912: Many years of State and Federal efforts to control the spread of insects and fungus diseases injurious to plants and plant products had passed prior to the

passage of the above-named act. Investigation had shown that at least half of the destructive insects in America were of foreign origin. By 1912, it was estimated that our annual losses from these imported scourges were about \$1,000,000,000.

The widely distributed and destructive San Jose scale, so called because first observed near the city of San Jose, California, was introduced from China with shipments of ornamental plants at some time prior to 1880. Some ten years later, it had begun its devastating march across the United States, where it is one of the most destructive pests of the deciduous fruits, such as the prune, peach, and apple. The native gall louse, *Phylloxera*, of the grape was first discovered in a vineyard near Sonoma, California, in 1873. Its destructive spread resulted in agitation which brought about the California quarantine act of March 4, 1881, "to protect the interests of horticulture and viticulture," which, as later modified, enabled California to close her borders against pests from other States and from foreign countries. It was Representative Caminetti of California who introduced, on January 15, 1892, the first bill for Federal legislation on this subject. On January 18, 1898, Representative Barlow of California introduced the second bill. A revision of these and other bills was introduced by Senator Flint of California on February 3, 1908. None of these bills reached passage, but they prepared the way for the Plant Quarantine Act of 1912, under which, with later amendments, present operations are conducted.

The Plant Quarantine Act, which is quite long, has two chief purposes, namely, to prevent the entry of plant pests with the importation of plants and plant products, and to control or eradicate any new pests gaining a limited foothold here. Briefly, it gives the Secretary of Agriculture authority to regulate and restrict the entry of nursery stock and other plants and plant products into the United States, and to prohibit completely such entry whenever necessary to the purposes of the act. Five amendments to the act have been made. Of these, the fourth was occasioned by a decision of the U. S. Supreme Court early in 1926, which ruled that State quarantine action was illegal and unwarranted when applying to interstate commerce. This ruling invalidated about two hundred State quarantines and inhibited the States from taking any pro-

tective action regarding plant pests moving from other States or countries. The amendment removed this inhibition, and specifically authorized the Secretary of Agriculture to cooperate with any State, territory, or district in the enforcement of any plant quarantine, and likewise gave the States authority to exercise police powers with respect to any article shipped in violation of a Federal plant quarantine. These provisions tremendously strengthened the cooperation of Federal and State authorities.

Terminal inspection of postal shipments: The agricultural appropriation act of March 4, 1935 (38 U. S. Stat. L, 1113) made provision under certain conditions for terminal inspection, by State authorities, of plants and plant products transmitted interstate through the mails. Previously a State could protect itself by quarantine against shipments by freight or express, but not against mail shipments of insect-infected or diseased plants. The procedure requires Federal interunit cooperation as well as Federal-State cooperation. Any State desiring to take advantage of this act must establish and maintain a terminal inspection service at one or more points. The proper State officer must submit to the U. S. Secretary of Agriculture a list of plants and plant products and the plant pests likely to be transmitted thereby, which in his judgment should be subject to terminal inspection. When approved, the list is transmitted by the Secretary of Agriculture to the Postmaster General, and thereafter all packages containing such plants or plant products, upon payment of the postage therefor, are forwarded by the postmaster at destination to the proper State officer for inspection. If already clean, or if cleansed by disinfection by the State officer, they are returned to the postmaster for transmission to the addresses. If infected and incapable of disinfection, they either may be returned to the sender at his expense or destroyed by the State authorities. The Federal government bears none of the expense, other than the time required of postal officials. California was particularly active in securing the passage of this law, and was the first State to take advantage of its provisions.

Quarantine in California.—Official quarantine procedures and relations in California may be taken as representative. The activities of the Federal Bureau of Plant Quarantine in California consist in port inspection and Mexican border inspection.

Port inspection: This work is conducted wholly in coöperation with the State Department of Agriculture. It consists almost entirely of the enforcement of Federal quarantines restricting or prohibiting the importation of plants or plant products from foreign countries and the Territory of Hawaii, in the effort to prevent the entry of injurious insects and plant diseases. The actual work of inspection is done entirely by employees of the State Department of Agriculture, who are employed by the Federal Department as collaborators at nominal salaries. In point of history, California had organized her own port-inspection service many years before the passage of the Federal plant-quarantine act in 1912.

The duties of these collaborators involve the inspection of vessels and airplanes arriving at California ports, including the examination of passengers' baggage, ships' stores, crews' quarters, etc., for contraband plant material; the inspection of plants and plant products imported under permit; and the examination of foreign parcel-post packages containing plant material. In addition to these duties, the collaborators at San Pedro and San Francisco supervise the fumigating of imported cotton to kill any insects it may have brought along. Occasionally some of the collaborators are called upon to assist in inspecting plant material which has been imported under special permit and planted in California. The purpose of this inspection is to make sure that no insect pests or plant diseases were overlooked when the material was examined as a condition of entry, and to see that it is being grown in accordance with the agreement entered into by the permittee.

There are now forty-three of these collaborators employed jointly by the Federal and State governments. Of these, six are at Sacramento, from whence supervision is exercised over the work at all the other points. Of the thirty-seven others, nineteen are at San Francisco, six at San Pedro, four at San Diego, three at Los Angeles, and one each at Crockett, Eureka, San Luis Obispo, Santa Barbara, and Santa Paula.

Under the third act cited above, there necessarily is coöperation with the Post Office Department in handling the plant shipments by mail. There also is some coöperation with the Customs Service of the Treasury Department in the inspection of incoming vessels and the belongings of their passengers.

Mexican border inspection: This activity is centered at two points, Calexico and San Ysidro, in Imperial and San Diego counties, respectively. The work, conducted in coöperation with the Treasury Department, comprises inspection of vehicles, freight, baggage, and personal effects of travelers from Mexico, for contraband plants and plant products; inspection and, if necessary, treatment of plants and plant products imported under permit; and inspection and certification of fruits and vegetables for export. At Calexico there is carried on, in addition to the above-named duties, the field inspection of cotton grown in the Baja California, or Mexican, part of the Imperial Valley, and the inspection of seed cotton and cottonseed at the gins in Mexicali, Mexico, for the presence of pink bollworm or other injurious insects. So far as known, no injurious plant disease or insect pest has crossed the border at either of these points since the work was begun.

The work at Calexico was established on June 1, 1917. Office space is leased. The total amount expended for the work from its establishment there to the end of the fiscal year 1931 is estimated at \$47,000. The work at San Ysidro began on July 1, 1926, and office space is provided in the Customhouse by the Treasury Department. The total amount expended there since the beginning of the work is estimated at \$16,000.

Study of Quarantine Efficiency: In 1930, the State Chamber of Commerce asked the University of California to undertake a study of the efficacy and economic effects of plant quarantines in California. The College of Agriculture of the University felt that such a study would be made more appropriately by some national body not in any way actively concerned with the quarantines. As no such agency was able to make the study, the College, with the concurrence of Federal and State quarantine agencies, appointed a committee of seven entomologists, plant pathologists, and agricultural economists for the purpose. Their comprehensive report (8—553 :1-276) was published in 1933. It acknowledged the generous coöperation of the Federal Bureau of Plant Quarantine, the Division of Quarantine Administration in the State Department of Agriculture, and many Federal, State, and county quarantine officials and others in California and other States.

An earlier independent study by the Plant Quarantine and Con-

trol Administration, discussing plant quarantines as affecting interstate shipments (97—80), and therefore of service to State officers, was published in 1930.

From Birds, Rodents, and Other Animals

Birds and other animals may be injurious to a single crop or group of crops or they may be injurious to many different crops at different seasons of the year. Little damage is done to crop plants by birds of any kind at any time, compared to their agricultural value as destroyers of insects and weed seeds, or to their value as game. The same is true of most animals other than insects. Among the rodents or gnawers, however, are some species or groups of species which do great damage to field crops, especially cereals and forages, and occasionally to orchard crops as well. The term rodent covers the various kinds of mice, moles, rats, pocket gophers, squirrels, prairie-dogs, rabbits, hedgehogs, porcupines, etc., and likewise such fur bearers as the badger, beaver, and others. Not all of the members of these groups are harmful to agriculture, and some that are injurious at some times, or to some crops at all times, are decidedly beneficial also in their destruction of weed seeds and plants or through eating noxious insects in their different stages. Some, the rabbits and squirrels, for example, provide meat and fur as well.

From the foregoing it will be seen that life-history and food-habit studies are fundamental to any accurate knowledge of the relations of animals and birds to the problems of plant industries. Such studies have been undertaken on a rather large scale by Federal, State, and private agencies over a long period of years. Most of the discussion of activities and relations in this field belongs properly to the chapter on Animal Resources in the succeeding volume on Natural Resources. There will be presented here only those activities which definitely relate to the protection of crops in general.

Federal agencies and activities.—The Bureau of Biological Survey (38—54) in the U. S. Department of Agriculture is the present Federal agency charged with matters in this field. It has developed from a Section of Ornithology established in 1885 and, after having had several names, achieved bureau status under its present

name in 1905. Of its six technical Divisions, only three, Food-Habits Research, Predatory-Animal and Rodent Control, and Game and Bird Conservation, are pertinent to the present discussion. Food-Habits Research is concerned mainly with statistical determinations of the total and seasonal character of the food supply of birds, mammals, and other animals, as revealed by stomach contents. Rodent Control includes studies of methods, demonstrations of procedure, and the actual conduct of campaigns of eradication or control. Game and Bird Conservation has many activities, of which only its supervision or prevention of the introduction of foreign species is germane here.

Many of the activities of the Biological Survey in this field are based on the provisions of two major Federal laws dealing with wild life. The famous Lacey Act of 1900 (38—54:70—83 and 25:248) provided for the first time for the exclusion of potentially harmful foreign species of birds and mammals. The law protecting migratory and insectivorous birds (38—54:93—105), first passed as a rider on the agricultural appropriation bill in 1913 and later declared unconstitutional, was finally embodied in the Migratory Bird Treaty with Great Britain, ratified in 1916, and in the Migratory Bird Treaty Act of 1918 (40 U. S. Stats. L, 755) making the provisions of a treaty effective in the United States. Both acts call for extensive relations between Federal and State agencies. The first requires continued collaboration between the Federal Departments of Agriculture and the Treasury in the matter of imports and exclusions. The Treaty requires the coöperation of the Departments of Agriculture and State in this country with each other, and with similar official agencies in Great Britain and Canada in the enactment of the treaty and in the enforcement of its provisions.

State agencies and activities.—The regulatory and control activities in the States are committed, usually, to the State department of agriculture, as the regulatory agency of the State. In the California Department this function is lodged in the Division of Entomology and Pest Control. Coöperation in researches and surveys often is given by the department of zoölogy of the State University or by the division of economic zoölogy or similar unit at the Agricultural Experiment Station. Assistance in demonstrations or

campaigns for control or eradication is given by the Federal-State agricultural extension service, an arm of the college of agriculture, which operates through the offices of the county farm advisors.

Federal-State cooperative relations.—The activities of the Federal and State agencies which have resulted in interrelations are presented below under two subheadings: Bird Injuries to Crops, and Rodent Injuries and Control.

Bird injuries to crops: The Division of Food-Habits Research studies the relation of the food habits of native and introduced species of birds and other animals, mostly mammals, to the various agricultural interests of the country. The principal investigations at present are in the damage to fruit buds by various birds (12—18:284), and the damage to various grain crops by different kinds of birds, especially blackbirds, bobolinks (ricebirds), and others. In California, which may be considered representative, injuries to both classes of crops occur. The grain injury in recent years has been confined chiefly to rice, which is attacked by blackbirds, ducks (14—26:83), and coots or mud hens. Many delicate questions of the comparative total and seasonal harmfulness and helpfulness of different species are involved.

Two headquarters are maintained in California, one at Marysville, Butte County, and one at San Diego. The work was started in response to requests from California fruit-growers for assistance in protecting their orchards. The work at San Diego was established in July, 1928. The headquarters at Marysville was opened in August, 1930, through the transfer of one of the two men previously stationed at San Diego. It has taken up the study of damage to rice by birds. All the work of this Division is conducted in the field, so that no offices and laboratories are established, other than the workers' residences.

As there is no division of injurious-bird control, the Federal Division of Food-Habits Research conducts some control activities in coöperation with various agencies within the State. Among these are the Bureau of Plant Quarantine and Pest Control of the California State Department of Agriculture; the Division of Fish and Game (16—16:243) in the State Department of Natural Resources; various county agricultural commissioners, and numerous commercial organizations, as well as other divisions of the U. S.

Biological Survey. Coöperation is wholly informal, under verbal agreements arrived at in conferences between leaders. Contributions by coöperating agencies are chiefly in the form of material for baits and labor for making and applying these in the field.

Rodent injuries and rodent control: The Division of Biological Investigations (now Wildlife Research) in the Federal Bureau of Biological Survey studies the food habits of rodents, including their destructiveness to grain, forage, and vegetable crops, and fruit trees. Several field stations are maintained, that at Tucson, Arizona, being coöperative with the State College of Agriculture and its Experiment Station. The biologist belonging there is employed jointly by the two agencies and the coöperative status is shown by the station (118—214, 234, 254).

The Division of Predatory-Animal and Rodent Control (now in Division of Game Management), through its section of Control-Methods Research, makes studies of methods of predator control and of the fundamental facts involved. It maintains field headquarters in several States but these are not located with any State agency. The subdivision of Control of Predatory Animals and Injurious Rodents (now Predator and Rodent Control) conducts demonstrations and campaigns for the control of such of these animals as are injurious to agriculture. This work is done wholly in coöperation with State agencies, or with other Federal agencies which administer Federal reservations or public domain. Numerous regional or district field headquarters are maintained, many of them being located with State agencies at the State capitals or State colleges or universities. Only its work on the control of rodents affects plant industries. The activities in rodent control date from about 1920, when provision was made in the annual appropriation act (38—54:284). The relations developed in California may be regarded as typical.

The work on control methods was started in California on July 1, 1924, as a result of requests from State and county agencies (12—13:164-65 and 17:406-12) as well as from private sources, for improved methods of control, in order to remove difficulties encountered in control campaigns. The work consists of basic studies to determine the fundamental factors of control, and of more or less emergency measures undertaken as the needs are presented

by coöperating agencies. The research includes the use of both solid and gaseous poisons, as well as traps, as control agencies. Determination of the effects of control campaigns on other forms of animal life also is a definite part of the program, as usually there is a delicate balance established in nature and the reduction or destruction of one pest may permit another to multiply devastatingly. For instance, the gradual advance of agriculture across the American continent increased the food supply of rodents and decreased the number of their predators.

The California headquarters for control-methods research at this time of writing, are at the Agricultural Experiment Station at Berkeley, where the Federal leader coöperates with the California Forest and Range Experiment Station of the Federal Forest Service, the Federal station occupying, in turn, an extensive suite of rooms in Giannini Hall, of the College of Agriculture. Before July 1, 1928, the headquarters were allotted space in the Post Office Building in Berkeley, a Federal building. A consulting relation is maintained with the Department of Vertebrate Zoölogy of the University of California on problems in taxonomy and ecology, as this Department has published numerous contributions to the subject (8—281 and 340; 9—296; 10—29; 12—7:597-708). The discussion of other coöperating agencies and coöperative activities and procedure in this work will be combined with similar discussion of the Subdivision of Rodent Control.

The actual control of ground squirrels has been an important economic effort in California since the early days of white settlement. In 1869 and 1870, the State legislature provided for the payment of bounties for squirrel and other rodent pests in counties where damage had been most severe. The bounty plan remained in effect until superseded by the ordinance inspector plan. As early as 1909, the Bureau of Biological Survey began investigation of methods of controlling rodent pests in California. Field operations to clear areas in National Forests of ground squirrels were begun in 1913, and have included poisoning operations on nearly all the National Forests, and on other public lands in many counties, particularly Kern, Lassen, Modoc, Siskiyou, and Mendocino. Representatives of the Bureau demonstrated the methods employed on Federal areas to State and county officials and to private land

owners interested, and aided in the educational campaign to develop organized community effort for the destruction of these pests.

California headquarters of the Federal Subdivision of Rodent Control were established in 1916, with an office later in the Berkeley Post Office Building. This work was begun because of urgent request for aid in controlling squirrels and gophers, which had caused general destruction of the range as well as severe losses to farm crops. These requests came from Federal, State, and county government agencies in California, and also from commercial organizations and private individuals. In January, 1921, the headquarters were removed to Sacramento, where space in the State Office Building was furnished by the Department of Agriculture. In the meantime, the County Agricultural Commissioners Act of 1917 had enabled county effort to assume definite form through plans suggested at a convention of commissioners held at Sacramento in November of that year. The plan included the furnishing, to land owners or lessees, at actual cost, of supplies of poisoned grain mixed according to the best known formulas. This further opened the way for improved operations under official supervision. Recent State legislation has made possible even closer coöperation between the agricultural commissioners and land owners within the county (13—109).

Because of the increasing prevalence of bubonic plague among ground squirrels during 1928 and 1929, in the southern and central coast counties, arrangement has been made with the State Department of Public Health that the State and county agricultural regulatory agencies in rodent control shall conduct the field operations against ground squirrels in areas of known plague infection, in order to prevent duplication and unnecessary overhead. The health agencies will continue to operate field laboratories and hunting squads to determine plague infection centers. In this work, the State coöperates with the U. S. Public Health Service of the Treasury Department (16—17:240-46).

The first major concern of the Subdivision is the coöperative control of rodents to prevent injury on Federal lands throughout the State, including the eighteen national forests and the numerous national parks, Indian reservations, military reservations, and

reclamation projects, as well as the public domain in general. The second major concern is to cooperate in the planning and carrying forward of similar control campaigns with State, county, and private agencies, on areas owned by these several agencies throughout the State. Through the development of this double program, the Federal Rodent-Control Subdivision has established its leadership in this important activity throughout the State. As a consequence, many thousands of acres of government land in the different reservations and areas mentioned have been relieved from damage by rodents. Through cooperative activity with the other agencies, ground squirrels have been controlled on more than 10,000,000 acres of privately owned farm and grazing lands in the Sacramento and San Joaquin Valleys and adjacent foothills, and along the coast from San Francisco to San Diego. A total of 15,000,000 acres has been involved in ground squirrel control under all agencies. Great benefits have resulted to field, orchard, garden, pasture, and forest crops, the estimated annual saving being not less than \$2,500,000. Publication of these results has been made through Federal, State, and private channels.

The total Federal budget for this work in 1931 was over \$15,000, and the total amount invested in the seven-year period from 1925 to 1931 about \$82,000. It is estimated that for each dollar expended from the Federal allotment of \$15,000 per annum, the State and the various counties combined expend not less than \$25, or a total of approximately \$375,000 annually. The average annual expenditure by the State is about \$40,000. In 1931, however, it was about \$75,000 if the amount expended for control of bubonic plague is included (16—17:240-46). In addition, it is estimated that private persons expend about \$500,000 annually for poison and other materials and for labor used in the application of the poison. The total saving resulting from this combined expenditure of nearly \$900,000 is estimated at not less than \$2,500,000 annually.

The pharmacology of rodent control by the use of thallium was published (92—238) in 1931, as the result of cooperative experiments begun in 1924 by the Federal Bureaus of Biological Survey and Chemistry and Soils.

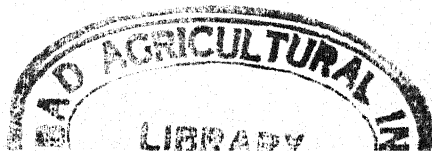
The very intensive cooperative relations developed both in control-methods research and in rodent-control campaigns will be dis-

cussed here together. The Federal agencies coöperating with the Bureau of Biological Survey include the Forest Service of the Department of Agriculture; the Bureau of Indian Affairs, the National Park Service, and the Reclamation Service of the Department of the Interior; and the commandants of the various reservations of the Army and Navy Departments. The official agencies within California include the former Bureau of Plant Quarantine and Pest Control of the State Department of Agriculture, some fifty county agricultural commissioners and their staff members, and over fifty county farm advisors representing the coöperative Agricultural Extension Service. In addition, numerous agricultural and commercial organizations and individuals coöperate indirectly through the county agencies.

There are formal written agreements covering the coöperation with the U. S. Forest Service and the State Department of Agriculture, including therein any formal coöperation with county agricultural commissioners. There are verbal understandings with the county farm advisors. Quarterly meetings of Federal and State leaders in rodent control are held, at which investigation and field projects are considered and plans of operation worked out, with reference to the funds available and the projected coöperation by the county or counties concerned. All projects are reviewed from the standpoint of the economic benefits to be derived from the expenditures proposed.

The agreement with the U. S. Forest Service designates certain projects, such as porcupine control on specified units of national forests, in coöperation with the forest officers, and includes arrangement for expenditure of the funds allocated.

The written project agreement between the Bureau of Biological Survey and the California State Department of Agriculture provides for the organization and supervision of systematic efforts for the destruction of jack rabbits, ground squirrels, pocket gophers, and other rodent pests in California. Supervision of Federal employees rests entirely with the Federal district leader and supervision of State employees with the State superintendent of rodent control. Each party pays the salaries of its own employees. The expenses for travel, materials, supplies, and office assistance may be paid by either party when properly authorized in writing. The



two leaders agree on plans, procedure, and personnel required for a given operation. Memorandums are prepared in duplicate, with a carbon copy for each administrative unit. Work in the national forests and on other public domain is directed by the Federal leader, while work done in coöperation with State agencies or the county agricultural commissioners is handled as agreed upon by Federal and State leaders. The last-named projects are subject to consideration and approval by the State Department of Agriculture, with a view to preventing overlapping and duplication of effort, and to insure effective correlation of the operations of all Federal, State, and local agencies.

Investigations, of interest to both parties, designed to determine improvements in methods of rodent control, are to be conducted by or under supervision of the Biological Survey, the designated agent of which (presumably the Subdivision of Control-Methods Research) is to confer with the State Director of Agriculture, or with his assistants in rodent control, and with the Federal district leader of rodent control regarding the plans for such investigation, and to make available to both parties the results obtained.

From Injurious Weeds

Weeds affect virtually all crops and, in the form of poisonous or wound-producing plants, they affect the livestock industries also. The present writer has estimated that they cause an average annual loss of at least \$3,000,000,000 in this country. The Federal Department of Agriculture has given relatively little attention to the weed problem. Various publications discussing weeds in general, or the more important species in particular, have been issued from time to time. Weed specialists have been employed at different times for varying periods, but there has been no well-recognized and increasing project, comparable to those developed in crop lines. The chief exception to this has been the work of the last quarter century and more on poisonous plants. This started in the Bureau of Plant Industry but was transferred to the Bureau of Animal Industry in 1915, because it concerned the livestock industries almost entirely.

Most of the Federal work on weed control has been done by men in charge of different crop projects, and in connection with their

other field experiments. This work includes studies, too, of those plants which are weeds because they are hosts to insects or plant diseases which also may affect crop plants. Many of these studies thus have occurred in projects which are coöperative with one or another of the States. The work of the Division of Seed Investigations in the Bureau of Plant Industry, discussed earlier in this section, covers the determination of the kinds and quantity of weed seeds found in commercial seeds, and also includes studies of the longevity of weed seeds.

Some ten or fifteen years ago the Division of Cereal Crops and Diseases received the coöperation of botanists and agronomists of all the State agricultural experiment stations in this country in compiling a list of the more troublesome weeds occurring in each State, together with an estimate of their relative harmfulness and the characters and habits which made them especially damaging. These data were later made available to a newly appointed weed expert in the Bureau of Plant Industry but have never been published.

Many of the States have carried on extensive investigations of weeds, from the standpoints of abundance and distribution, methods of spread, injury caused to various crops, and methods of control or eradication. These studies have been conducted mostly by the State agricultural experiment stations with some formal or informal coöperation between the different divisions interested, such as agronomy, botany, chemistry, horticulture, etc. There has been little relation with the Federal government except where, as noted above, the work was done in the interest of some coöperative crop-production or crop-protection project.

In recent years, as the economic side of agriculture has become increasingly important, and as improved transportation and increased travel have tended to scatter weeds more rapidly, there has developed a considerable volume of State legislation about weeds and weed control. Usually the enforcement of these laws is vested in the State department of agriculture as the proper regulatory agency for agriculture. The setup and procedure in California are fairly representative.

In California the State Department of Agriculture is the agency expressly charged with enforcement of the several general and spe-

cial laws regarding weed pests. This legislation is compiled in the Agricultural Statutes (11—Parts 1-2:76-83, 93-105, 128) and the recent Agricultural Code. Under the Political Code the Department is charged with preventing the introduction or dissemination of noxious weeds. It is authorized to maintain quarantine stations, to declare weed-free areas and prohibit the distribution and propagation of weeds therein, to control Johnson grass (12—16:456-64) under one special act, and to eradicate camel's thorn under another. All activities concerned with weeds are centered in the Bureau of Weeds and Weed Control of the State Department's Division of Plant Industry.

In California, as in many other States, there is extensive coöperation between the various agencies in weed research and weed control (12—20:349). Besides the State Department of Agriculture, the University of California through its Agricultural Experiment Station and Agricultural Extension Service, and the county agricultural commissioners take an active part. There is informal co-operation, also, with certain units of the U. S. Department of Agriculture and with other departments of the State government, and between the agricultural commissioners and certain municipal officials. That public interest in this subject is general and widespread is indicated by the fact that no less than twelve bills dealing in some way with weeds were introduced during the 1931 session of the California legislature.

In California, the general plant-pest law, which covers noxious weeds, is enforced locally by the county agricultural commissioner and his deputies and inspectors. He inspects, determines infestation, and posts and mails notices requiring removal within a specified period. If the work of removal is not performed by the owner it is done by the commissioner, and the expense becomes a tax lien on the property. If the property infested is public property, like a street, playground, park, or road, the notice is served on the proper city or county officer. The county agricultural commissioners are subject to supervision by the State Department of Agriculture and coöperate also with State and local agencies.

There is only minor Federal coöperation with the States in studies of weed habits and control methods, as has been indicated already. Some twenty years ago, the Federal Bureau of Plant In-

dustry assisted the California Experiment Station in its preparation of a comprehensive publication on the stock-poisoning plants of California (8—249). In 1927, the Federal Bureaus of Plant Industry and Forest Service investigated the goat-grass situation in California, in coöperation with the State Department of Agriculture and several county agricultural commissioners, the results being published by the State department (12—19:40-46). In 1930, arrangements were made by the State Department of Agriculture whereby the Federal Bureau of Plant Industry joined in a survey of Imperial, Riverside, Kern, Merced, Kings, and Fresno Counties, to determine the cost of a Federal-State-county campaign to eradicate the destructive camel's-thorn in those counties (12—19:773). Through an informal conference in 1931 between the U. S. Bureau of Biological Survey, the State Department of Agriculture, and the county agricultural commissioners, it was agreed that only high-grade grain, free from weed seeds, should be used in mixing poison baits for rodents injurious to crops (12—20:415).

The most wide-reaching and most intimate relations exist between the State Department and the State Experiment Station in research in the habits of weeds and in the chemicals, appliances, and methods for their control (10—54; 12—20:461-66). Both agencies receive full coöperation from the various units of the Agricultural Extension Service, which is a joint enterprise of the Federal, State, and county governments. For instance, the comprehensive *Circular 54* of the Extension Service, just cited, has three authors, one from the State Department of Agriculture and one each from the Division of Agronomy and the Division of Botany at the Experiment Station. It was published by the Extension Service primarily for the information of the county farm advisors, and is equally useful to the county agricultural commissioners.

In a study of the puncture vine in California, made by the State Department and the county agricultural commissioners and published by the Experiment Station (8—528) in 1932, acknowledgment is made of informal but very helpful assistance received from two College of Agriculture Divisions at the station and from two Divisions of the Federal Bureau of Plant Industry. There is co-operation also between the State Division of Highways and the

State Division of Forestry in the burning of weeds along State highways (17—6:90, 93).

Within the counties there is full coöperation not only between the farm advisors (of the Agricultural Extension Service) and the agricultural commissioners but also between the latter and city officials in the enforcement of the weed laws and regulations. For example, for November of 1930, it was recorded that the weed-eradication crews of Los Angeles County cleared two hundred miles of county roads and nearly four hundred miles of city streets in Los Angeles. For the latter service the county was reimbursed by the city of Los Angeles (12—19:68-69).

From Climatic Conditions

Among the functions of the Weather Bureau of the U. S. Department of Agriculture is that of issuing forecasts of expected climatic conditions. These forecasts, in turn, influence operations in many industries, including crop culture and handling in plant industry. Full discussion of activities and relations belonging to climate and weather has been given in the chapter on Climate and Weather, early in Volume I. The coöperation of Federal, State, and local official agencies in collecting weather data, and the lesser coöperation in the distribution of forecasts and warnings, have been fully presented in that chapter. Only brief mention of the general protection of plants from weather influences need be made here.

There are five different forecast activities which are utilized in protecting plant industries against climatic conditions, namely: (a) general weather forecasts; (b) special agricultural meteorology; (c) fruit-frost service; (d) harvest weather service; and (e) fruit-spray service. The first three are operated in California. The last two are comparatively unimportant in California, where no rain falls during the summer months in most of the agricultural areas.

The general forecasts and warnings are based on meteorological data obtained from observations, tabulated twice daily, and interpreted by experienced forecasters at district forecast centers, one of which is San Francisco. From these centers and from local offices are issued forecasts of general weather conditions at the sur-

face of the earth, including storms, frosts, and cold waves. These reports assist farmers in planning and carrying out many operations in tillage, cultivation, harvesting, and shipping of crops and crop products. In California, these forecasts are issued at Bakersfield, Eureka, Fresno, Los Angeles, Red Bluff, Redding, Sacramento, San Francisco, San Diego, and San Jose.

Under agricultural meteorology, special weather services are maintained during the growing season of the chief crops, in the principal agricultural sections. Observations are made each morning at some 400 places, collected by telegraph, prepared in bulletin form, and released within three hours. A weekly service, also, is maintained for each State, wherein bulletins are published giving general summaries of the weather for the week as a whole, and of its effect on crop growth and farming operations generally. Special weekly bulletins also show weather conditions over the great grazing areas of the West. These reports are issued from San Francisco.

The fruit-frost service, a special weather service, will be discussed later under Protection of Citrus Fruits, as it is primarily for the benefit of these crops that the service is maintained in California. In about 1923, the U. S. Weather Bureau coöperated with the Chemical Warfare Service of the U. S. Department of War in joint research on the efficiency of smoke screens as a protection from frost (133—51:396—99).

In about 1916, the Weather Bureau coöperated with the Bureau of Entomology in making tests of the shading effects produced on plants by the wire cages used by entomologists in determining the influence of insects on plants. A simple mathematical formula was published (131—1917:61; 133—44:501—6). Similar tests then were made for the Bureau of Plant Industry on the light-diminishing effects of the cloth used in the shade-growing of certain sensitive plants, such as tobacco (131—1919:62).

From Fire

Coöperation in the prevention and suppression of fires in other crops than forests has been confined largely to the Pacific States where the rainless summers make grass and grain fires an important problem. The coöperative activities are well illustrated by the objectives and procedures in California.

For more than two decades, in California, the State Forester has been promoting education on fire prevention among adults and juveniles in rural areas, organizing counties for the suppression of forest, grass, and grain fires, and demonstrating effective apparatus and methods. The county school superintendents, acting with the State Department of Education, have coöperated with State and Federal agencies in fire-prevention education through the distribution of literature and the promotion of fire-prevention campaigns in schools. County boards of supervisors coöperate financially with State and Federal agencies in the construction of fire-lookout stations and towers, and with municipalities in supplying fire-prevention organization and equipment.

During the conservation activities of the World War period, a first-aid manual prepared by the U. S. Forest Service was widely distributed by the State forester to the larger ranches and harvesting crews, as well as to lumber companies (15—7[1917—18]:98). In 1919, the California legislature passed a new act providing for coöperation of the State forester with the Federal Department of Agriculture and with county and municipal agencies in the control of forest fires. These were defined in the act to include fires burning uncontrolled in brush, grass, or grain. The counties previously had been authorized to appropriate funds to control forest, grass, and grain fires. About thirty counties organized some four hundred rural fire companies through the efforts of the extension forester. Many of these were primarily for the control of grass and grain fires.

In June, 1928, the governor of California named a Committee on Rural Fires, consisting of the directors of the three State Departments of Agriculture, Natural Resources, and Public Works. It conferred with other State officials, with county officers, and with interested commercial agencies. Plans were formulated which resulted in State legislation placing rural fire districts on a uniform basis of organization and equipment and giving the State forester general supervision over fire equipment and the organization of county fire-protection districts. Hundreds of miles of roadsides, mostly along main travelled highways where fire hazards are great, were burned in order to prevent the spread of roadside fires to grain and hay fields. One result of these protective activities was

a lowering of the premium charged for insurance of growing grain.

Through collaboration of the Extension Division of the University of California College of Agriculture, the equipment section of the Division of Highways in the State Department of Public Works took part in a series of meetings of rural fire fighters. It also was represented on a committee to draft standards and specifications for rural fire-fighting trucks, and in its Sacramento shops eight combination fire trucks were constructed for the State Division of Forestry. In this task, the equipment section acknowledged information and assistance given by the Division of Agricultural Engineering of the College of Agriculture (17—7:169-70).

From Alkaline Waters

Some discussion of the protection of crop plants from the effects of alkalis has been given in the chapter on Soils. There is no sharp separation, of course, between the alkalis of soils and those of waters. A few that concern only the water supply are discussed here.

Between 1902 and 1904, the Federal Bureau of Chemistry and the Office of Experiment Stations coöperated on a study of the irrigation waters of Louisiana and Texas. Drought had caused low water in rivers and bayous and permitted the backing up of salt water from the Gulf and consequent injury to rice fields (104—1902:143). In recent years similar conditions in California have permitted the backing up of salt water from San Francisco Bay as far as the valuable truck farms of the Sacramento-San Joaquin Delta, with immense resultant damage. Considerable coöperation between Federal and State engineers and other technicians has resulted, in the endeavor to protect these crops.

For several years the Division of Western Irrigation Agriculture, in the U. S. Bureau of Plant Industry, has conducted research into the quantities of boron occurring in natural waters in California. Boron is very harmful to many plants if its concentration exceeds certain low levels. There has been informal coöperation by Federal agencies, as the Bureau of Reclamation and the Geological Survey (Hydrographic Branch), in the Department of the Interior, and the Division of Irrigation of the Bureau of Agricultural Engineering, in the Department of Agriculture. The most recent publication (92—448), in 1935, acknowledged the coöperation of

the University of California, whose Citrus Experiment Station at Riverside made available the facilities of the Rubidoux Laboratory, and whose extension service assisted in the survey and collection of water samples. Similar coöperation has been extended by the State engineer, of the Bureau of Water Resources in the California Department of Natural Resources, by the Imperial Irrigation District, and by the Los Angeles City Bureau of Water Works and Supply. An earlier publication (92—264) acknowledges the co-operation of rangers of the U. S. Forest Service and officials of the Santa Clara Conservation District (pp. 34, 37) in obtaining samples of water for analysis.

In Washington, the State College, through its Irrigation Branch Station at Prosser, and the Federal Bureau of Plant Industry, through its Division of Western Irrigation Agriculture, coöperated in a study of surface and subsurface waters on the Yakima and Klamath reclamation projects. The results (142—228) were published in 1928.

The publications listed in the Literature Cited at the end of this chapter which have been cited in this subsection on General Plant Protection in the section on Plant Production and Protection are Nos. 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 20, 25, 38, 90, 92, 97, 104, 112, 118, 119, 123, 131, 133, and 142.

3. CEREAL CROPS

IT IS FITTING to begin the discussion of crop groups with the cereal crops because they constitute the most important single element in the food supply of the human race. They are the chief source of the starch in the human diet, the principal other starchy foods being potato, sweet potato and yam, taro, and banana (plantain). Cereals also are prime sources of the concentrates in livestock rations.

INTRODUCTION

Before taking up the treatment of coöperative activities concerned with individual crops, it is necessary to present the definition and scope of the subject, to record the official agencies involved in such activities, and to present certain activities concerned with cereals as a whole.

Definition and Scope

The word cereals is restricted technically to grain-producing grasses. Of these, the best known are wheat (and wheat allies), rye, barley, oat, rice, maize, sorghum, and various millets used by the white race. In addition, numerous wild grasses are used as cereals by aboriginal peoples. Popularly, some other plants furnishing starchy seeds used for the making of flour are classed with the true cereals. The only one grown in American is buckwheat, which for convenience is here treated with the cereals.

The work officially done with cereals covers both production and protection. Under production may be listed varietal comparisons, fertilizer responses, physiologic reactions, breeding studies, machinery economics, handling technique, chemical composition, product processing, and product quality and utilization. Under protection are placed activities in the control of bacterial, fungus, and virus diseases, insect pests, injurious animals and birds, and weeds, as well as unfavorable climatic influences in field and storage.

Agencies Involved

The official agencies concerned with cereal production and protection are found at three levels of government, Federal, State, and county. Naturally, municipal agencies have little relation to farm crops such as cereals.

Federal agencies.—The principal Federal agencies are the Bureau of Plant Industry and the Bureau of Entomology (and Plant Quarantine). Of secondary importance are the Bureaus of Chemistry and Soils, Biological Survey, Extension Service, Agricultural Economics, Home Economics, and Agricultural Engineering, all of the U. S. Department of Agriculture. In Plant Industry, the Division of Cereal Crops and Diseases is charged with the work. Protecting cereals from insects is done by the Division of Cereal and Forage Insects and the Division of Domestic Plant Quarantines in the Bureau of Entomology and Plant Quarantine. Various divisions in the other Federal bureaus named cooperate in the activities from time to time.

State agencies.—The principal State agencies are the College of Agriculture, with its Agricultural Experiment Station and Agri-

cultural Extension Service, and the State Department of Agriculture, usually with activities in control of injurious diseases, insects, animals, and weeds. In the experiment stations, the divisions of agronomy (crops and soils), entomology, and plant pathology are the primary units, with the divisions of chemistry, agricultural economics, agricultural engineering, and zoölogy assisting from time to time. The crop specialists of the extension service, through the county agricultural agent, carry forward the various production and protection campaigns decided upon.

County agencies.—The chief county agencies are the boards of county commissioners or supervisors, the county agricultural agent (farm advisor) and his staff, and, in California, the county agricultural commissioner, with any control or eradication specialists who may be employed directly by the county.

GENERAL CEREAL ACTIVITIES

The coöperative undertakings with cereals usually involve several cereal crops, such as wheat, oat, barley, and rye, on the same station. In the early days of coöperation the results with all these crops, and others, usually were contained in a single publication. The early work is discussed, therefore, under a general heading, with three subsections: Development of Cereal Investigations, Production and Improvement, and Protection.

Development of Cereal Investigations

Definite experiments with cereal crops, by the U. S. Department of Agriculture, date from about 1895, when the Division of Vegetable Physiology and Pathology began a study of the resistance of domestic and foreign wheats to cold and rust (130—24), and grew about 1000 sorts and varieties for three years. This was followed by the introduction of hardy cereal varieties from Russia in 1900 and their coöperative testing at the South Dakota, North Dakota, and Nebraska Experiment Stations thereafter. This in turn was followed by the beginning of widespread coöperation in the testing of introduced and American varieties in the Great Plains, Great Basin, and Pacific Coast areas.

In 1903 was begun the systematic establishment of cereal experiments on independent Federal field stations and on coöperating

State agricultural experiment stations and substations throughout the Great Plains, and by 1910 or 1912 the area was well covered. Many of the stations were those listed previously in the discussion of Rotation and Tillage Studies. In 1905 the coöperation was extended to California, by 1908 to Utah, and by 1912 successively to Oregon, Idaho, and Washington.

In the humid eastern States, coöperative studies were begun in Iowa, Maryland, Georgia, and Tennessee between 1904 and 1914. Later, the investigations of cereal diseases increased in scope and extensive studies were made in coöperation with several of the States named or indicated above, as well as with Illinois, Indiana, Minnesota, and New York (Cornell) Agricultural Experiment Stations.

At first the work was chiefly with wheat, the wheat allies (emmer, spelt, and einkorn), oat, barley, rye, and grain sorghums. Later, seed-flax and rice received attention. Maize, which had been handled by an independent Office of Corn Investigations until 1919, became one of the major projects after the two offices of Corn Investigations and Cereal Investigations were united in that year. Drastic cuts in appropriations in 1920 caused the abandonment of cereal investigations on several stations, but later the work was greatly expanded again.

Production and Improvement

The chief reason for the expansion of coöperative investigations in the production and improvement of cereal crops was the rapid increase in settlement and resettlement of dry-land areas shortly after the opening of the twentieth century. Three dominant factors in production, namely, drought, cold with scant snow cover, and rust, made improvement in varieties and cropping methods imperative, if farming was to be successful under these unfavorable conditions.

In response to the demand so created, the Office of Grain Investigations (later Office of Cereal Investigations, and Office and then Division of Cereal Crops and Diseases) of the Federal Bureau of Plant Industry entered widely into coöperation with the State agricultural experiment stations in the areas named. Its work covered varietal improvement and methods of production, including

seeding and harvesting practices, tillage methods, and rotation influences. A little later an Office of Dry-Land Agriculture was established in the Bureau and undertook an extensive series of experiments on tillage and rotation practices in the Great Plains. As these involved other crops than cereals, they have been discussed already under Tillage and Rotation, earlier in this chapter. Rotation and tillage studies remained a responsibility of Cereal Investigations at some points in the Great Plains Area, and on all cereal stations in the Great Basin and Pacific Coast Areas.

The Office of Cereal Crops and Diseases was the first unit of the Bureau of Plant Industry to bring all of its field work into coöperation with the States in which it was located. Coöperative agreements, called memorandums of understanding, were signed jointly by the Bureau and the experiment station involved. In general, these agreements (see chapter 1, Principles and Practice) merely recited the principles of coöperation rather than the details of procedure. In resulting publications, the Bureau was obligated to place major emphasis on the regional aspects of the problem and the State on the more local aspects.

Humid eastern States.—Federal-State cereal experiments in coöperation with the Maryland Station were begun in 1904 and the results to 1913 were published (90—336) in 1916. The general cereal experiments were later extended to Georgia, Iowa, Minnesota, New York (Cornell), and Tennessee. Many of the results were published for each crop separately and so do not have mention under general cereals. Later coöperative experiments in Minnesota were published (55—264) in 1930.

The Great Plains Area.—Independent Federal studies of dry-land cereal production were begun in Texas in 1903 and coöperative experiments in most of the other States except Oklahoma between 1906 and 1912. The work was done on State stations, State substations, and Federal field stations, the Federal agency coöperating on the former and the State agency coöperating on some of these latter. Many of these stations were named in the previous discussion of Rotation and Tillage. Numerous coöperative publications have resulted, some in the Federal series and some in State series.

In Colorado, the results of eight years at the Akron Substation were published (90—402) in 1916, and of fifteen years (90—1287)

in 1925. In Kansas, the coöperative experiments at Hays Branch Station from 1912 to 1923 were published (92—14) in 1927. For Montana, the coöperative results with all small grains from 1908 to 1915 were published by both agencies under joint authorship (60—110; 90—398). In Nebraska, studies of the time of seeding spring cereals, conducted with the Federal Office of Dry-Land Agriculture, were issued (63—213) in 1926 and the coöperative testing of cereal varieties at the North Platte Substation with the Federal Division of Cereal Crops and Diseases was published (63—272) in 1932.

In North Dakota, there was a large volume of coöperative cereal studies because of the several substations located in different parts of the State, and an unusual number of publications because the cereal data were published in annual or multiannual reports of the substations issued as Station bulletins. Coöperative cereal results from the Dickinson Substation for 1907—13 appeared (90—33) in 1914, and later reports (74—138, 160, and 189) from 1920 to 1925. From the Edgeley Substation coöperative data for 1914—20 and for 1921 were issued (74—145 and 161), and from the Hettinger Substation data were published (74—150) in 1921. From the Williston Substation the periods covered were 1908—14 (90—270), 1914—20 (74—158), and 1914—24 (74—190). The coöperation was discontinued at Williston in 1918, and likewise at Edgeley and Hettinger. On the Federal field station at Mandan, the cereal experiments were coöperative with the Division of Dry-Land Agriculture and were published under joint authorship (90—1301) in 1925, for the years 1913—22.

In South Dakota, coöperative cereal results at the Highmore Substation from 1905—12 were published (90—39) in 1914. Results from 1903 to 1910 were published by the State (86—124) under joint authorship in 1910, and the results of nineteen years of work (86—272) in 1932. At the Belle Fourche Reclamation Project, Newell, South Dakota, the cereal experiments were coöperative between the two Plant Industry Divisions, but the State Station entered the coöperation later on. The results of 1908—13 were published (90—297) in 1915 and those for 1912—20 were issued (90—1039) in 1922. In Wyoming, experiments begun at the Cheyenne Experiment Farm in 1912 were in coöperation first with the Wyo-

ming Board of Farm Commissioners and then with the Wyoming Station (90—430).

Many of the publications previously cited under Rotation and Tillage were intimately concerned with cereal-production problems in dry-land areas.

Great Basin and Pacific Northwest.—Federal-State coöperation in cereal-production experiments began in 1904 in California, which will be discussed by itself. In Utah, coöperation began in 1907 and in the Pacific Northwest in 1911 and 1912.

In Utah, the coöperation with the Utah Station, begun in 1907 on the Nephi Substation, was discontinued in 1920, because of reduced Federal appropriations. Later it was renewed at the Substation and established at the State Station. The Substation results have been published by the Federal (90—30) or the State agency (136—175 and 222) at intervals to 1930.

In Idaho, the coöperative cereal-production activities were begun in about 1912 at the Aberdeen Substation, under both dry-land and irrigated-land conditions. More recently the coöperation was extended to the State Station also. In Oregon, the coöperation was begun in 1911 on the Sherman County Branch Station, Moro (90—498), where it still continues. Shortly after, coöperation was extended to the Harney Valley Branch Station at Burns (78—204 and 209), but was discontinued in 1920. Similar coöperative studies were begun at the Adams Branch Station at Lind, Washington, in 1912, and continued (142—167) to 1920, when Federal appropriations were reduced.

California.—The program of coöperative cereal investigations in California differs from that in many States in that it has not been continuous. In order to picture the activities and the relationships in them, therefore, it is necessary to discuss successive separate projects in sequence. The principal lines of work, not in order of chronological development, have been the production of wheat and rice, with some attention to barley and oat, and the protection of these crops from fungus diseases and insects, with recent attention to rodent control and fire prevention.

Several Federal and State agencies have been concerned with the introduction, production, improvement, and protection of the cereal crops in California. In the U. S. Department of Agriculture,

divisions of several different bureaus have taken part. Among these divisions are Cereal Crops and Diseases, Bureau of Plant Industry; Cereal and Forage Insects, Bureau of Entomology; Cereal Chemistry (under various names) in the Bureau of Chemistry; Rodent Control, in the Bureau of Biological Survey; and Grain Investigations, in the Bureau of Agricultural Economics. Units of the California Agricultural Experiment Station taking part in the coöperation have been the Divisions of Agronomy, Chemistry, Entomology, Genetics, Irrigation Engineering, and Plant Pathology.

Formal coöperation began as early as 1905, and exists now in larger volume, though perhaps not in wider scope, than at any previous time. From 1905 to 1906 there was formal and from 1907 to 1911 there was informal coöperation in one or another of the activities. Then until late in the second decade of this century there apparently was little collaboration of any kind, but during the third decade it increased steadily to its present maximum, involving more agencies and covering much larger activities. The lack of collaboration during the second decade was due in large measure to both earlier and current personal difficulties between the representatives of some of the various agencies, which led to the development of wholly independent operations. The present changed status has been due to the growing spirit of coöperation in public affairs, and to changes in personnel in both Federal and State organizations.

The first coöperative activity covered cereal production and improvement, the second provided for an exchange of wheat seed and later of soil to determine environmental effects, the third was on cereal diseases, the fourth was concerned with rice, and the fifth renewed the first. It may be worth while to examine in detail how the coöperation began, and how and why it waned and then increased again.

Early coöperative studies: In the autumn of 1904, a representative from the California Station and one from the Federal Bureau of Plant Industry came into contact with various California groups commercially interested in cereals, especially wheat, such as the growers, millers, and shippers, and with such commercial organizations as the Merchants' Exchange, the State Board of Trade, and the Sacramento Valley Development Association. Through

their joint efforts, support was developed for a concerted movement to improve the cereals of California. Immediate action resulted.

Through private subscription, two cereal stations were provided, one at Modesto, Stanislaus County, in the San Joaquin Valley, and the other at Yuba City, Sutter County, in the Sacramento Valley. Each comprised twenty acres of land, and each was leased for a period of years, with the option of renewing the lease vested in the California Station. Under the influence of this movement the legislature of California, early in 1905, appropriated the sum of \$10,000 for the ensuing biennium, to be expended by the Governor for cereal improvement.

Arrangements were made to coöperate with the Bureau of Plant Industry in work on cereal improvement in California, utilizing the two cereal stations and the funds provided by the legislature. The coöperative agreement, signed in the spring of 1905, provided that the California Station was to furnish land, buildings, teams, machinery, farm labor, seeds, and any results already obtained that were likely to be of value to the project. The Bureau of Plant Industry was to furnish seed of old and new varieties and hybrids in its possession, and a special agent, agreeable to both parties, who should conduct the work in the field. New varieties developed were to be distributed in those portions of the State to which they were adapted; the seed produced from material of Federal origin was to be divided equally; any large plats sown for increase of seed were to be at the expense of the State; and the proceeds from all seed sold by the State were to be used in financing the investigations. Copies of the annual reports were to be supplied to both parties, and the results could be used by either party, with proper credit given to the other. In publications, the State was to give preference to results of State interest, and the Bureau to those of national interest. It may be noted, however, that the Federal publication (121—178) issued after the formal agreement had been terminated, comprised information almost wholly of local or State interest.

Owing to the late start, only varietal testing could be done in the crop year 1905. Tillage, rotation, weed control, and breeding experiments were added at both stations in 1906. Some 566 varieties

and strains were grown, largely derived from the Federal experiments in other States. Though the formal coöperation seems to have been terminated (8—185) at the end of the crop year 1906, the work was continued by both agencies for several years. The Federal experiments were transferred to another tract of land at Ceres, not far from Modesto, where they were continued until 1909, after which they were transferred to the Federal Plant Introduction Garden at Chico. Though the formal coöperation ended, informal coöperation between the State and Federal representatives apparently was maintained as long as the Federal work remained at Ceres, because the State published (8—211) Federal data for 1907–10 and acknowledged the coöperation of the Federal agent, and the Federal publication cited appears to contain data for as late as 1909 from the State plats at Modesto.

Summary of later projects: The second Federal-State collaboration, begun in 1905 also, provided for an exchange of wheat seed between three different States in order to determine the influence of environment on quality. This was expanded in 1907 to include also an exchange of soil and was so continued for several years (8—216). This project will be fully discussed under wheat. The third coöperative activity in cereals was an investigation of cereal diseases, started in 1918 under formal agreement and still continuing. It will be presented under protection of the crops involved—wheat, oat, and barley. The fourth Federal-State coöperation was an informal survey of the situation regarding rice growing in California in 1908. The resulting rice experiment station, however, was started in 1912 by the Federal agency alone, and did not become a coöperative enterprise until 1925. It will be fully discussed under rice. The fifth coöperative activity was a resumption of cereal investigations in Federal-State coöperation in 1922, as presented below.

Recent coöperative studies: At the end of the crop season of 1909, the Federal cereal experiments, conducted first coöperatively at Modesto and then independently at Ceres, in the San Joaquin Valley, were transferred to the Plant Introduction Garden at Chico, California. Experiments in the varietal comparison and improvement of the cereals, principally wheat, but with some attention to barley and oats, were conducted there during the



twelve years from 1910 to 1921 (90—1172). The Introduction Garden is wholly a Federal station, and there was no active co-operation with the California Station in the cereal studies. By personal agreement between the Federal and State workers, however, some exchange of desirable varieties and of information took place.

At the end of the crop season in 1921, a formal coöperative agreement was effected between the Federal Bureau of Plant Industry, for its Office of Cereal Crops and Diseases, and the California Station, for its Division of Agronomy. Under this agreement, the cereal experiments were transferred from Chico to the State Experiment Station at University Farm, Davis, where collaborative cereal investigations have been conducted continuously ever since. The coöperative agreement under which the work is done, being relatively recent, is the standardized form discussed in the chapter on Principles and Practices.

The work in general has consisted of agronomic experiments on wheat, oats, and barley, including varietal comparisons, the breeding of improved varieties, and genetic studies on the inheritance of desirable qualities.

During the progress of these coöperative investigations, the tests of varieties, either introduced or produced by breeding, have discovered varieties better adapted to conditions in California, and several of these now are grown on relatively large acreages, replacing less desirable sorts previously grown commercially. These results have been published in bulletins and circulars by both agencies, and carried out to the farmers of the State directly by the coöperative Agricultural Extension Service, with which close contact is maintained. Not the least of the advantages of coöperative relations in research within any State lies in having all the effective local machinery of State organization available for the prompt and widespread distribution of results.

The Federal contribution for salaries and labor at Davis has varied between \$3000 and \$4000 annually, and probably has amounted to \$35,000 in the ten years since the coöperative project was begun. This is in addition to the cost of Federal supervision. The State Experiment Station furnishes about fifteen acres of land for the joint experiment, and office and laboratory space for the coöperative representative, as well as the necessary teams,

machinery, and farm labor. It is difficult to estimate the annual value of the State contribution, but undoubtedly it is much larger in this particular instance than is the Federal allotment. The amount of surplus grain resulting from the collaboration, and made available for use, sale, or distribution by the State Station, annually, probably has an average annual value of about \$100. In 1930 it amounted to about \$109.

The Federal scientific representative is given an appointment by the University of California College of Agriculture with the title "Associate in Agronomy" in the Experiment Station, and is listed as a cooperative employee of the California Station, in the annual Federal publication entitled: "Workers in Subjects Pertaining to Agriculture in State Agricultural Colleges and Experiment Stations."

Standardization and registration of varieties.—Increasing numbers of named varieties of cereals caused confusion and resulted in the attempts at standardization and classification mentioned under wheat and barley. This was followed by cooperative efforts to guide the introduction of new varieties through a plan for registration. A cooperative agreement was effected between the Bureau of Plant Industry and the American Society of Agronomy, in 1926, whereby the Bureau agreed to maintain a register and a collection of standard varieties. The society in turn agreed to make the necessary field comparisons of commercial and proposed varieties and certify worthy sorts for registration. Committees were established for different crops, the chairman usually being the Federal specialist and the members representatives of State stations.

Studies of combined harvester-thresher.—The advent of the combined harvester-thresher, or combine, into the Great Plains and then into the humid East created several new problems in cereal production. An extensive investigation of these was undertaken by the Federal Bureaus of Agricultural Economics, Agricultural Engineering, and Plant Industry, in cooperation with the corresponding divisions in various State stations in the two regions (92—70 and 244) from 1926 onward. This cooperative activity has been discussed fully in the chapter on Agricultural Engineering and needs no more than mention here.

The economic need to change from sack to bulk handling of grain harvested with the combine in the Pacific Northwest resulted in a coöperative study by the Federal Bureau of Agricultural Economics and the State Stations of Idaho, Oregon, and Washington. The results were published (93—161) in 1931.

Protection

Protection required for cereals is chiefly against fungus diseases and insects, with less important activities against birds, rodents, and the effects of climate. Most fungi and many insects are rather closely limited to one particular kind of crop. This leaves relatively little material for discussion under cereals in general.

From fungus diseases.—The fungus causing the stem rust of cereals attacks wheat, the wheat allies, barley, and oats. Its overwhelming importance on wheat, however, makes it logical to discuss it under that crop. Some molds and rots attack both maize and the small grains but are of economic importance primarily on the former, with which they will be discussed.

From insects.—The Hessian fly attacks most cereal crops as well as wild grasses, but there has been very little coöperation by the Federal Bureau of Entomology with State agencies in efforts to control it. The Division of Cereal and Forage Insects, of the Federal Bureau, has maintained field laboratories in California since 1912 but has not entered into coöperation with the State Division of Entomology and Pest Control. It did acknowledge assistance, however, received from California agencies in the Hessian-fly study made in that State (92—81). A North Dakota study of the pale western cutworm (74—179), published in 1924, was conducted and authored jointly by the Station Division, and the Federal Bureau, of Entomology.

In Illinois, a recent study of protection against insects affecting stored grain was conducted coöperatively by the State Natural History Survey and the Departments of Entomology and Animal Husbandry of the State Station (35—359).

From miscellaneous influences.—Much of the coöperative activity in the control of rodents and birds, discussed under General Crop Protection, was directed toward protection of cereal crops. So is much of the effort in fire prevention in rural California.

One of the widespread problems of cereal protection is to reduce the hazard of winter injury. One of the methods used is drilling in furrows deeper than ordinarily made. Data obtained in coöperative Kansas experiments were published (43—13) in 1924.

WHEAT

Wheat is the most important of all cereals in America. The volume of investigation in its production, improvement, and protection has been enormous and much of it has been coöperative. The major production objectives have been: (a) To produce more winter-hardy varieties and by means of these and special cultural practices to extend the areas of winter-wheat production, and (b) to displace soft wheats with harder wheats. The major protective problems have been to control smuts, imperfect fungi, and nematodes by cheap and effective treatments, and to control rusts through breeding resistant varieties and eradicating the widely distributed European barberry.

Varietal Classification, Registration, and Distribution

A knowledge of the characters, relationships, and geographic distribution of wheat varieties in a country as large as the United States, is fundamental to their improvement and use. In 1914, the Federal Division of Cereal Crops and Diseases began the collection and study of all findable varieties in America. These were grown in extensive classification nurseries at eighteen points in fourteen States, in one or more of the six years 1915–20. Most of these were in coöperation with State experiment stations located in the different climatic areas of the country. After their expression of characteristics under different sets of environing conditions had been recorded, a comprehensive classification was published (90—1074) in 1922. Material received under several hundred names was reduced to 229 recognized varieties. The growing, study, and classification of all available varieties was repeated from 1930 to 1933, with similar coöperation, and the results published (92—459) in 1935. Seventy-seven new varieties are included and 68 formerly included are omitted.

After the publication of the classification of then existing wheat varieties, it became evident that there should be some control over

the naming and distribution of new varieties. Accordingly, in 1926, an agreement was effected between the Federal Bureau of Plant Industry and the American Society of Agronomy, as discussed more fully under General Cereal Activities. Under this agreement, a Committee on Registration of Wheat Varieties was formed by the society, and the Bureau maintains the records of registration and the samples of the plants and grain. The 229 standard varieties recognized in the classification were registered first. Forty new varieties had been registered to the end of 1931, and 77 by 1935.

The geographic and acreage distributions of all recognized varieties are important agronomic and commercial data. This information has been obtained three times, at five-year intervals, as of 1919, 1924, and 1929, through schedules sent to tens of thousands of crop reporters. Extensive coöperation is entailed between the Federal Bureaus of Agricultural Economics and Plant Industry. The Division of Crop and Livestock Estimates in the former Bureau prints, distributes, and assembles the schedules. The Graphic Section of the Division makes the maps showing location and acreage of each variety. The Division of Cereal Crops and Diseases interprets the schedules and computes the data. The results of the three surveys were published (90—1074 and 1498; 93—283) in 1922, 1929, and 1933, respectively. The acreages are calculated from the percentages of the varieties in the total wheat acreages of the counties as determined by the Federal five-year censuses.

Production and Improvement

Rotation and tillage studies already have been discussed under General Plant Production. Extensive cereal experiments have been discussed and publications cited under General Cereal Production. Most of the activities in these two series of studies were concerned primarily with wheat because it is the dominant crop in dry-land areas. In some cases, the results of these general experiments were published separately for each crop, as were substantially all the breeding researches which followed.

In general, the humid East grows soft red winter wheats, the dry-land Great Plains Area produces hard red winter wheats in the southern and central thirds and hard red spring and durum wheats in the northern third, while the Great Basin and Pacific

Coast produce hard red winter wheats and soft white wheats. As the natural commercial groups of wheat are thus localized geographically, the discussion may be either geographic or by groups, or both. A few general phases of wheat production must be presented first.

Environmental influence on composition.—The two principal environmental influences on cereals are climate and soil. Attempts to determine their influence are not new. From 1883 to 1886, the Division of Chemistry in the U. S. Department of Agriculture reported on an investigation of the composition of American wheat (105—1, 4, and 9) and corn. The samples were obtained from private coöperators and from coöperating State colleges, some of which, as for example Colorado, Michigan, and Ohio, grew numerous varieties especially for these analyses.

Some twenty years later, new studies were planned in order to determine the influence of climate and soil on the composition of wheat.

Interstate exchange of seed: In 1905, a coöperative study of the effect of environment on wheat quality was begun at the Experiment Station on the University Farm at Davis, California. The Federal agencies in the coöperation were the Laboratory of Vegetable-Physiological Chemistry, Bureau of Chemistry, and the Office of Grain Investigations, Bureau of Plant Industry, both in the U. S. Department of Agriculture. The State agencies were the Divisions of Agronomy and Chemistry at the California Station and similar units in the other States. These experiments were part of a series devised by the Federal Bureau of Chemistry, under the general name of Tri-Local Experiments on the Influence of Environment on the Composition of Wheat. They comprised an annual interchange of seed wheat grown at each of three points in three different States having different conditions of soil and climate.

Two experiments of this series were conducted coöperatively in California. In one, Kubanka, a spring variety of durum wheat grown originally in South Dakota, was transferred for growing also in California and in Kansas. In the second, Crimean, a winter variety of hard red common wheat, grown originally in Kansas in 1905, was transferred for growing also in California and in Texas.

Data for the years 1905-9 are given by the Federal agency (105-128) in 1910 and conclusions quoted by the State (8-216:557) in 1911.

At the beginning of the experiment in 1905, wheat of each variety grown in one of the three selected States was seeded again in that State, and also sent to each of the other two for seeding. In 1906 and each year thereafter, the wheat thus grown in each of the States was seeded again in that State, and sent to each of the other two, for similar sowing. In 1907 and thereafter, therefore, three plats of a given variety were grown side by side in each State, one of the three being sown with home-grown seed, the others with seed sent annually from each of the other States and derived from the home-grown plat of the year before. The primary purpose was to discover whether the protein quality and other characters which marked the wheat in its own State would be maintained under the different conditions of soil and climate in each of the other States.

Interstate exchange of soil: In 1907, a second coöperative experiment on the influence of environment on the quality of wheat was begun in California (8-216:558) and continued until 1910. The same Federal and California agencies were concerned. The experiment consisted of a bilocal interchange of sufficient soil to make a small plat six feet long, 3 feet wide, and 3 feet deep. Soil from the California Station at Davis was sent to the Hays Branch Station in Kansas, and soil from that Branch Station was sent to Davis, California. The soil was taken up in six-inch layers, and relaid in the other State with the layers in the same relative position. In each State, also, a similar adjacent plot of local soil was prepared in an exactly identical way. Each such plot in each State was divided into halves, and on one half was grown the variety of wheat from local seed and, on the other half, the same variety from seed produced in the other State.

In 1908, a new trilocal experiment in exchange of soil was inaugurated in coöperation with the same Federal agencies and continued until 1912. The three stations involved were the two named above and the State Station at College Park, Maryland. The Federal Department was coöperating with all the States and the exchange was a Federal-State rather than an interstate coöperation. Sufficient soil to make a plat five feet square and three feet

deep was transported in three-inch layers from each State to each of the others. The procedure was the same as in the previous experiment with reference to the interchange of both soil and seed (8—216 :566 ; 41—1 :275).

Vernalization.—The process of starting the germination of seeds and then chilling them for a period of time, before sowing, is called vernalization. The claim is made that it shortens the growing period and increases yields. Many tests of variations of the process have been made in the United States, but few of them coöperatively. One recent Federal-State study (93—325), issued in 1934, involved coöperation by the Kansas, Nebraska, Montana, and North Dakota Stations in growing the crops from the vernalized seed.

Milling and baking quality.—The prime use of wheat is for flour making. To determine its quality for this purpose is of the utmost importance. Much research has been devoted to methods of such determination and to actual testing of new varieties and strains before commercial distribution. The work includes complete chemical analyses, as well as the blending of flours, the making of the dough, and the baking of the loaf.

Because of the expense and the technical knowledge involved, as well as a persisting belief that this was a commercial field, only a few of the State agricultural colleges have provided for such research. The Federal Bureau of Chemistry has a small baking laboratory and the Bureau of Agricultural Economics has a more recent and more extensive equipment in connection with determining grain grades. The Bureau of Plant Industry has not established any laboratory but has coöperated informally and formally with these other two Bureaus over a long period of years. During recent years it has provided a chemist in the milling laboratory as its contribution to the joint milling and baking research on wheat. A comprehensive study of the milling and baking qualities of American wheats (90—1183), begun in 1915, was published in 1924.

The States having milling laboratories with which the Federal Division of Cereal Crops and Diseases has coöperated include Kansas, Minnesota, and North Dakota. The Grain Division also, of the Bureau of Agricultural Economics, has coöperated with

these States (74—114). In Kansas the Station Divisions of Agronomy and Milling Industry have studied coöperatively the relation of tillage to milling and baking quality (43—19) and the characters of the Blackhull variety (42—241), published in 1926 and 1927 respectively. A similar coöperation between the Station Divisions of Milling Industry and Agricultural Engineering on quality as affected by farm storage (43—32) was issued in 1932.

In a Minnesota Station study of small-grain varieties (55—264), published in 1930, and coöperative with the Federal Division of Cereal Crops and Diseases, the station Division of Agricultural Biochemistry made the milling and baking studies. In similar coöperative studies at the Nebraska Station, on Nebraska winter wheats, credit was given to the Federal milling laboratory for furnishing the milling and baking data (64—31). At the North Dakota Station, the three Divisions, Agronomy, Cereal Milling, and Extension, published a coöperative survey of the 1928 wheat crop (74—222) in 1928.

Wheat standards and grades.—The Office of Grain Standardization was formed in the Bureau of Plant Industry a few years after the Bureau was established in 1901. In the work of formulating standards there was informal coöperation with the Office of Cereal Investigations. In August, 1916, when the Office of Markets and Rural Organization was made independent of Plant Industry, the Office of Grain Standardization was placed under the joint administration of the two units and so continued until the Bureau of Markets was established in 1917. During these two years there was coöperation between the two agencies in determining the quality of wheats. One such study, published in 1916, discussed the so-called Humpback wheat (90—478) and another in 1917 was concerned with the quality of Montana-grown wheats (90—522). A third compared several classes of American wheats as to the factors of quality (90—557).

Since this work became part of the activities of the Grain Division of the present Bureau of Agricultural Economics, the informal coöperation of the two Bureaus has continued, as noted previously under Grain Standardization. One phase of the coöperation was the joint study of the combined harvester-thresher, discussed fully in the chapter on Agricultural Engineering and

briefly under General Cereal Production in the present chapter.

Soft red winter wheats.—The wheats of this class are confined largely to the humid eastern States although a few varieties are grown sparingly in the Far West. At the beginning of this century, when the Federal Department of Agriculture began field investigations, wheat growing had been long established in the older sections. The pressing problems were on the newer lands in the West. Consequently there has been relatively little Federal-State coöperation in production and improvement directly concerned with these winter wheats, but a comparatively large coöperation in protection from wheat diseases.

In a few States there has been formal Federal-State coöperation in production, continued over shorter or longer periods. Coöperation was begun in Maryland about thirty years ago (90—336) and progressively later in Georgia, Tennessee, and at the New York (Cornell) Station. In New York the research was directed toward the genetic principles governing inheritance of certain characters in wheat and contributions were published by both agencies (71—53; 41—28) between 1922 and 1924. Minor coöperation with the Iowa Station was with hard red winter wheats and therefore properly belongs to the Great Plains research. That in Minnesota is similar, and also includes hard red spring wheats.

Hard red winter wheats.—These are the dominant wheats of the central section of the Great Plains Area, especially Kansas, with a northwestward extension across eastern Wyoming and Montana. They occur again in small parts of the Great Basin and Columbia Basin. Originally they were Russian wheats, introduced by German Mennonite immigrants from southern Russia to Kansas in the seventies. From about 1899 onward, many additional introductions have been made from Russia, Hungary, and Roumania.

Coöperative Federal-State experiments were begun in Kansas (121—240) and Nebraska (121—78 and 269) thirty or more years ago, and have been continued in varying volume ever since. Independent Federal experiments were begun in Texas (121—283) at the same time. About twenty-five years ago coöperative experiments were begun with these wheats in Colorado, Montana, South Dakota, and Wyoming, and independent Federal studies in New Mexico and Oklahoma. A small amount of coöperative work has

been done in Iowa also, although Iowa belongs not to the semiarid Great Plains but rather to the humid East. In about 1927, a new regional program of research in these wheats was arranged at a joint conference of Federal and State administrators, agronomists, and pathologists. At this time the work in New Mexico and Oklahoma was made coöperative with the States and a new project was started in Texas, the independent work having been discontinued in 1920.

Regional results: Under the memorandums of coöperative agreement the Federal Bureau is obligated to give major attention to regional and national aspects when publishing. Summaries of the relation of cultural methods, such as rotation and tillage, to wheat production were published by the Office of Dry-Land Agriculture, for both coöperative and independent experiments (90—595) in 1917 and later. Summaries of the results of varietal comparison and rates, depths, and times of seeding were published by the Office of Cereal Crops and Diseases (90—1276) in 1925. A compilation of results from nursery tests in the breeding program from 1921 to 1928 was published (92—136) in 1929, including some data from coöperation in Minnesota also. Studies in winter hardiness are presented under protection of wheat from climate.

Results by States: Some early and mid-period results from individual States were issued by the Federal Bureau, in spite of the formal agreement. Instances include the Colorado experiments on the Akron Substation, owned by the State (90—402), the Montana experiments on the Judith Basin Substation (90—398), and the Wyoming results from the Cheyenne Field Station (90—430), all published in 1916. For Colorado, the long-time results from the Akron Substation were issued by the State (19—359) in 1928, under joint Federal-State authorship. Production methods for the years 1926—32, inclusive, were published (19—404) in 1933, under joint Federal-State authorship, including two Federal Divisions. In Kansas, the State summarized wheat production (42—248) in 1929, with results obtained in coöperation with two Federal Divisions. A comprehensive discussion of twenty years of coöperative testing of varieties and strains of winter wheat was published (43—30) in 1932, under joint authorship. In Montana, a discussion of early coöperative results (60—110) was followed by a dis-

cussion of winter and spring wheats for central Montana (60—203) in 1927 and the results of coöperative studies of cultivation methods for winter and spring wheats (60—205) in the same year.

In Nebraska, the State summarized data on seedbed preparation for winter wheat (63—178) in 1921, including coöperative results from the North Platte Substation, and presented sixteen years of grain production at that Substation (63—193), including rotation and tillage studies, under joint authorship in 1923. Studies on winter wheat in western Nebraska (63—179), including North Platte coöperation, were issued in 1922 and on the coöperative dry-farming investigations at the Scotts Bluff Substation (63—192) in 1923. In a summary of winter-wheat investigations (64—31), issued in 1925, credit was given to the Milling and Baking Laboratory of the Federal Bureau of Agricultural Economics and to the Division of Cereal Crops and Diseases of the Bureau of Plant Industry for coöperation in milling and baking data. A general discussion of winter wheat in Nebraska, under Federal-State authorship, was issued (63—283) in 1933, after the coöperation had been extended to include the State Experiment Station.

In North Dakota, the experiment station summarized all coöperative work with winter wheat in the State (74—151) in 1921 and revised it (74—169) in 1923. In 1927 it published (74—209) a general discussion of wheat, including winter wheat, in the State. These data were presented from time to time also in annual or less frequent reports of the various coöperating substations, as cited under General Cereal Production.

In South Dakota, a discussion of coöperative experiments with varieties and strains of wheat (86—146) was issued in 1913. A discussion of winter grain, including wheat, based chiefly on coöperative experiments (86—161), was issued in 1915. In 1927 and 1929 the Wyoming Station published studies of production methods for winter wheat (148—150, 151, and 161) begun in 1922 in coöperation with the two Federal Divisions, including rotation and tillage previously cited. Varietal tests of winter and spring wheats, begun in 1916 at the Sheridan Field Station in coöperation with the two Federal Divisions, were published (148—171) in 1930.

Hard red spring wheats.—The wheats of this group, dominant in the northern Great Plains and extending eastward into the

prairies of Minnesota, have been the objects of much coöperative investigation. They are of high quality for bread making but are restricted to an area which they occupy without much competition from hard winter wheats, and they have long been subject to destructive epidemics of stem rust. The coöperative studies of the rust organism, together with the breeding for rust resistance, will be presented under Protection. The Fife wheats, leading representatives of this group, moved with the advancing frontier and were pioneer varieties in this area.

Early coöperative experiments: Coöperative Federal-State investigation of the hard spring wheats began some thirty years ago with the extensive cereal experiments of the entire Great Plains Area. The general cultural experiments discussed under Rotation and Tillage were concerned with these wheats among others in part of the Dakotas, Wyoming, and Montana. In the early years most of the States included reports on all spring grains, or at least all spring wheats, in the same publication; for example, dry-farm grain tests in Montana (60—110) and wheat strains and yields in South Dakota (86—146). In the same way, the Federal Office of Cereal Investigations published the coöperative results with all cereals at one station, or in one State, in a single bulletin. Examples are those covering the Akron, Colorado, Field Station (90—402), the Judith Basin Substation in Montana (90—398), the Dickinson (90—33) and Williston (90—270) Substations in North Dakota, the Belle Fourche Experiment Farm (90—297), and all coöperation covering cereals in South Dakota (90—39).

Special publications devoted to these wheats also were issued. The Federal Office of Cereal Investigations compiled the results of all available experiments, coöperative and independent, with Marquis wheat, the leading variety of this group (90—400) and a similar treatment of Ghirka (90—450), both in 1916. Results obtained on all spring wheats, covering collaboration with the States by the three Plant Industry Offices of Cereal Investigations, Dry-Land Agriculture, and Western Irrigation Agriculture (90—878) were issued in 1920, while in 1921 and 1923, respectively, results of studies of water use by spring wheat (90—1004) and of water storage in soil and its use by spring wheat (90—1139) were published by Dry-Land Agriculture and coöperating States.

Recent coöperative experiments: In recent years much more emphasis has been placed on breeding and improvement, and several coöperative Federal publications have resulted. Inheritance in spring wheat in Montana was published (90—1403) in 1926. The inheritance of growth habit, winter hardiness, and stem-rust reaction in crosses between a winter and a spring wheat, grown in co-operation with the Minnesota and Montana Stations, was issued (92—218) in 1931. Coöperative studies of the yield and protein content of wheat in North Dakota were published (41—47:129) in 1932.

The more local results of varietal and production-method experiments were published by the coöperating States. Colorado wheat varieties (19—359) was published in 1928 and methods of wheat production (19—404) in 1933, both under joint authorship. Small grain studies in Minnesota, reported on (55—264) in 1930, included milling and baking studies. Results of wheat experiments at the Northern Montana Branch Station (60—197) were issued in 1926. Bulletins on wheats in central Montana (60—203) and cultural methods for winter and spring wheats in the Judith Basin (60—205) were published in 1927 and represented State coöperation with the Federal Divisions of Cereal Crops and Diseases and Dry-Land Agriculture, respectively.

Results of coöperative experiments on wheats for North Dakota were published (74—209) in 1927. Numerous Station bulletins containing the annual or longer-period reports of the various co-operating Substations (74—138, 145, 150, 158, 160, 161, 189, 235, and 248) were issued through the years. The results of South Dakota coöperation included spring-wheat experiments (86—201), published in 1923, and nineteen years of crop yields at the Highmore Substation (86—272) in 1932. In Wyoming, Federal coöperation included one or both of the two Divisions named above under Montana and covered varietal tests at the Sheridan Field Station from 1916 onward (148—171) and spring-wheat tillage at the Archer Field Station (148—173) from 1914 to 1929, both issued in 1930.

Durum wheats.—Durum wheats are those large-kerneled, very hard, wheats which are used commercially for the manufacture of macaroni and the other edible pastes. Most of the varieties were

introduced from Russia and the Mediterranean region (121—7) by the Federal government, beginning in about 1900. This entailed assistance and coöperation from officers of various foreign governments. One or two varieties already were grown in this country by Russian immigrants to North Dakota.

Early coöperative experiments: The early introductions were grown at stations and substations of coöperating States of the Great Plains, especially Nebraska, South Dakota, and North Dakota (121—77). One chief objective was to determine the bread-making qualities of these new wheats, and much attention was given to their chemical analyses by the Bureau of Plant Industry (121—3 and 70), in the early 1900's, with assistance from the Federal Bureau of Chemistry. By agreement, however, a large part of the chemical work was done coöperatively by the South Dakota Station (86—82). Several States joined in making tests of the comparative palatability of loaves baked from durum and common wheats (121—70). Through the coöperation of the Consular Division of the Federal Department of State, a study was made of the European manufacture of edible pastes from durum wheats, the results being published (121—20) in 1902.

With the expansion of Federal-State coöperation on to numerous State stations and substations in the Great Plains and the Far West, from 1905 onward, the testing of durum-wheat varieties was expanded rapidly, especially in the Dakotas, Montana, and Wyoming. Results were reported in many of the publications already referred to under General Cereal Production and General Wheat Production, as well as in the earlier section on Rotation and Tillage. Many of these varietal results, both coöperative and independent, were summarized in one comprehensive Federal publication (90—618) in 1918.

Recent coöperative experiments: While the varietal and production-method experiments have been continued, more emphasis has been placed on the breeding of improved varieties in the recent period. One Federal publication was devoted to the improvement of the Kubanka variety by selection (90—1192) in coöperation with the North Dakota Station. In addition, substantially all of the publications on spring-wheat experiments, referred to in the preceding section on Hard Red Spring Wheats, contained a consider-

able volume of data on durum wheats, which also are spring wheats. The durum wheats, also, were tested extensively in the Great Basin and Pacific Coast Areas, and the publications referred to in the next section on Soft White Wheats were concerned with all the classes of wheat grown in those areas, including durum wheats.

Soft white wheats.—These wheats really belong to two different commercial classes, common wheats and club wheats, but do not need to be treated separately. The white wheats are grown chiefly in the Great Basin and Pacific Coast Areas, although small acreages occur in Michigan and New York. They provide pastry flours and have been a chief article of export to the Orient.

The white wheats compete in this western territory with soft red winter wheats, a small acreage of hard red spring wheats, and an increasing acreage of hard red winter wheats of higher milling value. Because of this occurrence of several different classes of wheat in the same area, most coöperative publications from these States deal with all classes rather than with the white wheats only. The few treating of the white wheats alone will be mentioned particularly.

Coöperative Federal-State wheat experiments in these two areas began in 1905 in California, in 1908 in Utah, and during the period from 1911 to 1916 in Idaho, Oregon, and Washington. The experiments were located on dry-land substations, for the most part.

Early coöperative experiments: In California, the coöperative experiments, fully described under general cereal production, were conducted at Ceres in the San Joaquin Valley and near Yuba City in the Sacramento Valley during 1905 and 1906, under formal agreement. During the next four or five years there was informal coöperation through exchange of data from independent experiments, the Federal work in the San Joaquin Valley having been moved to Modesto (8—185, 211; 121—78). Thereafter, there was no coöperation in wheat investigation in California until 1922, when the independent Federal experiments at Chico were discontinued and coöperation begun on the University of California Station at Davis.

For the Nephi Substation in Utah, the coöperative wheat-varietal experiments were published by the Federal agency (90—30) in 1913 and the production-methods data (90—157) in 1914. The

State station summarized sixteen years of mostly coöperative dry-farming experiments with wheat (136—175) in 1920. The wheat experiments at the Sherman County Branch Station in Oregon were published (90—498) in 1917. The State published in 1914 and 1917 on summer-fallow experiments at this Branch Station (78—119 and 144), and in 1918 on similar experiments at the Harney Valley Branch Station (78—150).

Recent coöperative experiments: In California, formal Federal-State coöperation in wheat improvement was begun at the Experiment Station at Davis in 1922 and results of inheritance studies were published (92—39) in 1928. In 1930, Utah summarized a quarter century of partly coöperative dry-farming experiments with cereals (136—222). The formal coöperation extended to the State Station also. For Oregon, the results of coöperative experiments in wheat growing after fallow in eastern Oregon were issued (78—190) in 1922, and spring crops for eastern Oregon, including both coöperating substations, under joint authorship (78—204), in 1924. Coöperative experiments in dry-farm crop rotations, mostly wheat, on the Sherman County Substation were published (78—209) in 1924 also. Studies of wheat varieties for the Columbia Basin, including wheat nurseries grown in several counties by county agents of the Extension Service, were published (78—308) in 1932. In Washington, in 1916, coöperative wheat experiments were begun on the Adams Branch Station. The principles of summer-fallow tillage were published by the State (142—183) in 1924, and wheat varieties for Washington (142—207) under joint authorship in 1926.

Results of wheat-production experiments on dry lands in Utah, Oregon, and Washington were summarized (90—1173) under joint authorship in 1923 and again (92—329) in 1932. Varietal and other experiments with White Australian wheat, in coöperation with the Oregon Station, were published (90—877) in 1920.

Protection from Environment

The principal environmental factors from which wheat requires protection are fungus diseases, virus diseases, insects, nematodes, and adversities of climate. The chief fungus diseases fall into three groups—rusts, smuts, and foot rots. There are three principal

rusts—stem rust, leaf rust, and stripe rust. Likewise there are three principal smuts—bunt, or stinking smut, loose smut, and flag smut. To avoid having too many ranks of headings, such natural headings and subheadings as "From Fungus Diseases" and such subheadings as "Wheat Rusts" and "Wheat Smuts" are omitted, and each of the rusts and smuts is given a heading coördinate in rank with the more inclusive ones concerned with foot rots, virus diseases, insect pests, and climatic factors. The principal Federal agency has been the Federal Division of Cereal Crops and Diseases. Other agencies will be mentioned specifically.

Stem rust of wheat.—This disease, recognized by the Romans, was one of the first investigated by the Federal Department. The early wheat experiments of the Division of Vegetable Physiology and Pathology, begun in 1895, with informal coöperation in a few States, were concerned with the reaction of wheat varieties to rusts, as indicated by publications (130—16; 121—63) in 1899 and 1904. In 1908, formal coöperation on stem-rust research was begun by the Federal Division and the Minnesota Experiment Station. In 1918 similar coöperation began with the California Station. For short periods, minor coöperation existed at the Nebraska, North Dakota, and Wisconsin Stations.

Minnesota Station: The coöperation in stem-rust research, begun at the Minnesota Experiment Station in 1908, is still in progress. It has covered the morphology of the fungus, its life history as related to epidemiology, its physiologic specialization to cereals and grasses and their varieties, the collection and identification of spores from on land and in the air over wide areas, the effects of chemical dusts and of fertilizer applications on the incidence of rust, and breeding of wheats for rust resistance. The barberry eradication campaign, although intimately connected with the research activities, will be discussed separately.

The many-sided research program required a rather large coöperative staff at the Division of Botany and Plant Pathology of the Experiment Station. Some were paid wholly by Federal funds, some wholly by the State, and some jointly by both agencies. The station furnished extensive facilities in laboratories, greenhouses, equipment, services, and supervision. The Federal agency also supplied traveling expenses, some equipment, and supervision.

The studies in morphology were designed first to discover if there were measurable differences of size or shape between the spores of the physiologic variety occurring on wheat and those of the varieties occurring on barley, oat, rye, and different grasses (41—15:221, 16:43, 24:539, and 28:541). Secondly, it was designed to find out if any measurable differences of size existed in the spores of the different physiologic forms.

Studies of life history were made to determine any weak link in the chain of seasonal progress of the rust fungus from grasses, stubble, and straw in spring to the barberry plant, thence back to young wheat plants in summer and so on to the formation of winter spores again in the autumn. These studies included histological (41—39:929) and morphological factors in resistance (41—23:375, 27:381, and 27:725). Conditions affecting the development of the aecial stage on the barberry were reported (92—314) in 1932. The relation of stem rust on grasses to that on wheat also was investigated (41—6:813 and 28:541).

The observation that, in any given epidemic, some varieties succumbed and others escaped, whereas in the next season the reverse might be true, led to critical research which in 1917 discovered the fact of physiologic specialization in this rust (41—10:429). Numerous physiologic forms were found to occur, each able to infect a certain variety or varieties but not other varieties. More than seventy such specialized forms have been isolated by differential nurseries containing large numbers of wheat varieties. The research has resulted in numerous coöperative publications, mostly in the *Federal-State Journal of Agricultural Research* (41—13:651, 14:111, 15:221, and 16:103) between 1917 and 1919. The Minnesota Station summarized the work on physiologic specialization (56—8) in 1922, under joint authorship. The relation of the barberry to the origin and persistence of physiologic forms of this rust was determined and published (41—48:953) in 1934, under joint authorship of the Minnesota Station and the Cereal Crops and Barberry Eradication Divisions of the Federal Bureau.

In order to get specimens of stem rust for use in determining the geographic distribution of the physiologic forms of rust, the aid of pathologists in other States was obtained. To determine if the spores migrate long distances on either lower or higher air cur-

rents, airplanes were employed. An ingenious device was developed to collect the spores and keep them free from other contaminations until after they had been incubated in a laboratory to determine if they were living or dead. The War Department coöperated heartily in furnishing planes and pilots for the necessary flights (41—24:599). The Post Office Department also coöperated through its aerial mail service stations. Private flying fields also aided in local flights.

Coöperative experiments in the dusting of wheat plots with sulphur to prevent rust also were conducted, and published in *Phytopathology* in 1925 and 1926. The effect of the application of fertilizers on the development of rust on wheat was reported (41—27:341) in 1924. Another experiment determined the effect of rust infection on the water requirements of wheat (41—27:107) and another the effect of light and temperature on the development of the rust (41—50:861).

Breeding wheats for rust resistance was begun at the Minnesota Station in coöperation with the Division of Botany and Plant Pathology in 1908, when the rust studies were started. In 1916, the coöperation was enlarged to include the Division of Genetics, then a section in the Division of Agronomy. In 1920, the genetic results from crosses of common wheats, durum wheats, and emmer were published (41—19:523). Other coöperative breeding studies were published (41—24:457, 24:979, 24:997, 27, 48:31, and 48:59) from 1923 to 1934, the last in joint authorship. Morphological and physiological studies of wheat in connection with stem-rust resistance appeared (92—266) in 1931 under joint authorship.

Nebraska, North Dakota, and Wisconsin: In Nebraska, coöperation between the Station Divisions of Agronomy and Plant Pathology resulted in a publication on wheat rust (64—39) in 1926. Federal-State coöperation produced a bulletin (64—42) on stem rust in Nebraska in 1927, under joint authorship. At the North Dakota Station coöperative experiments in breeding durum wheats for rust resistance were begun in 1928, with results published (92—385) in 1933. In Wisconsin, rust in seed wheat and its relation to seedling infection was studied coöperatively (41—19:257) in 1920.

California Station: The coöperation on stem-rust research in

California is of a highly specialized nature. As the coöperative rust studies at the Minnesota Station progressed, there was need of more intimate knowledge of the nature of the delicate reaction between the cells of the wheat plant and those of the invading fungus. In the collaborative California research, personnel had been provided for just this type of study. The Federal Department agreement was with the Division of Agronomy at the California Station, but valuable contributions were made also by the Divisions of Genetics and Plant Pathology. Studies were made of the reactions of different varieties of wheat and emmer to different physiologic forms of stem rust (41—23:131, 26:571, and 32:701) between 1921 and 1925. Later, when the phenomenon of heterothallism was under investigation, this was made the subject of research and two contributions were published (41—40:585 and 47:1) in 1930 and 1933. In connection with the coöperative cereal experiments begun in 1922 on the University Farm at Davis, some studies were made of the inheritance of stem-rust resistance in crosses of Kota and Hard Federation wheats (41—29:1) and published in 1924.

Barberry eradication.—In 1918, on recommendation of the plant pathologists of important grain-growing States, the Division of Cereal Crops and Diseases, in the Federal Bureau of Plant Industry, entered into formal coöperation with the extension division of the agricultural college in each of thirteen north-central grain-growing States on a campaign to eradicate the common (European) barberry. The States were Colorado, Illinois, Indiana, Iowa, Michigan, Minnesota, Montana, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin, and Wyoming. This action was based on the fact that the stem rust of cereals overwinters on grasses, straw, and grain stubble in spore form which infects the barberry but cannot reinfect grains directly. After developing in the barberry tissues, however, a spore form is produced which infects grain directly. Removal of the barberries, therefore, would prevent the direct spring infection.

The then Federal Horticultural Board established a quarantine which prohibited shipment of barberry plants into any of the thirteen States. The several States enacted laws making it illegal to have or grow such barberries and making their removal compulsory. By Federal-State agreement, a gigantic educational cam-

paigned was begun, to inform some 30,000,000 people about the harmful nature of the barberry and enlist their coöperation in its eradication. All agricultural agencies, including the public school system, coöperated in carrying the story of stem rust and the barberry to the entire population. Every available method of publicity was used, including press material, popular bulletins, charts, lectures, exhibits, lantern slides, motion pictures, cartoons and animated cartoons, mock trials, and radio addresses. Civic, social, agricultural, and commercial organizations took part.

The headquarters of the campaign was in Washington, D. C., with a field-research headquarters at the Minnesota Experiment Station, and a State headquarters at the agricultural college of each State. College students, mostly in agriculture and science, were used during the summers. They were rigidly selected, trained, and examined in coöperation with the several land-grant colleges. Every effort was made to tell the story so effectively that owners would remove their bushes gladly. Failing that, the force of community sentiment was allowed to operate on unwilling owners. It was the pride of the service that the eradication was voluntary on the part of the rural and urban homeowners. Only in the rarest instances was it necessary for the States to invoke their laws in order to accomplish eradication. Some 18,000,000 plants were destroyed from 1918 to 1930.

In carrying on the educational campaign, several popular publications were made available in quantity. Among these were the story of the barberry and stem rust (91—1058 and 1544), *Chemical Eradication of the Barberry* (94—268 and 332), *The Common Barberry and How to Kill It* (94—356), *Bread or Barberries* (97—7), and *A Dangerous Neighbor* (97—131), all prepared as a part of the coöperative campaign.

No little research in methods of chemical eradication became necessary when it was discovered that digging multiplied the bushes. In the Federal coöperation with the Wisconsin Station and the Wisconsin State Department of Agriculture, many and varied mechanical and chemical methods were tested (90—1451), including sodium arsenite (90—1316), from 1921 to 1925, but salt was most widely used.

In the joint investigation at the Minnesota Station a comprehen-

sive study was made of the susceptibility and resistance of various species of *Berberis* (barberry) and related genuses to attacks by stem rust (92—300).

Besides the literature of the coöperating extension services, most of the State stations published the technical data on the relation of the barberry to stem rust of wheat and other cereals and also on the methods of barberry eradication. Among the prominent bulletins of this group are those by Colorado (19—315) in 1927, under Federal-State authorship and with extension-service coöperation; by Iowa (40—57) in 1920; by Montana (60—180 and 196) under joint authorship in 1925 and 1926; and by Wisconsin (146—357) in 1923, in a bulletin issued jointly by the College of Agriculture and the State Department of Agriculture (Division of Insect and Plant Disease Control) and under joint authorship of the State Station and the Federal Division, with the collaboration of the State Extension Division. This bulletin of the Station is also *Bulletin 55* of the State Department.

Leaf rust on wheat.—A formal coöperative project for research on the leaf rusts of cereals was inaugurated by the Federal Division of Cereal Crops and Diseases at the Purdue University (Indiana) Station in 1920. By a three-way agreement, a portion of the investigation was allocated in 1920 to the Kansas Station, the principal investigator in Indiana being recognized as the leader of the project in both stations. Special cytological research was conducted in coöperation with the California Station also. In the coöperative experiments in breeding wheats for stem-rust resistance at the Minnesota Station, some reactions to leaf rust were determined also (41—48:31 and 48:59) in 1929 and 1930.

Indiana Station: The research had much the same scope as already described for stem-rust studies at the Minnesota Station. The aecial stage of the leaf rust was discovered and demonstrated on *Thalictrum* and the results published (41—22:151) in 1921. Physiologic specialization was published in *Phytopathology* (81—16:89) in 1926. The effect of infection on wheat yields was issued (41—40:417) in 1930. The effect of leaf-rust infection on winter wheat was studied from 1930 onward, including coöperation by the State Chemist in determining chemical composition, and was published (41—48:1049) in 1934 under joint authorship.

Indiana-Kansas coöperation: Certain phases of the problem were worked out jointly by the two stations. Studies of the inheritance of resistance were begun in 1920 and published (41—32:931) in 1926 under three-agency authorship. Physiologic specialization in leaf rust was investigated jointly, beginning in 1926, and the results published (92—313) in 1932.

Kansas Station: The coöperative studies of leaf rust in Kansas began as early as 1920. The studies of inheritance of resistance, and of physiologic specialization, are noted above under Indiana-Kansas coöperation. Experiments on the relation of age of wheat plants to infection, begun in 1925, were published (41—38:147) in 1929 and the effects of infection on the functioning of the wheat plant (41—49:955) in 1934.

California Station: When critical cytological research in the method and results of infection of wheat by the leaf-rust fungus was needed, the work was done at the California Station because of specially qualified Federal-State personnel located there, as noted under stem rust. Studies were made of one physiologic form on two wheat varieties (41—33:201 and 34:697) and published in 1926 and 1927. Later, the phenomenon of heterothallism was investigated, as in stem rust also, and published (41—44:733) in 1932.

Stripe rust of wheat.—The Federal-State coöperative research in stripe rust (*Puccinia glumarum*) was located at the Idaho Experiment Station by formal agreement in 1920. These experiments had been started at the Oregon Station in 1917, whence they were transferred to Idaho. The combined results of the studies of the life history made at both stations were published (41—24:607) in 1923. Specialized or physiological varieties of this rust were studied by both stations during the same period and published (41—25:363) in 1923 also. A general summary of the knowledge of stripe rust was issued (41—29:209) in 1924 under Federal-State authorship.

In the cytological research in cereal rusts conducted coöperatively at the California Station, as described under stem rust, the method of infection of stripe rust was studied on wheat and a wild brome grass and the results published (41—36:487) in 1928.

Bunts or stinking smuts of wheat.—There are two closely related species (*Tilletia tritici* and *T. levis*) which are called bunt. It

was long believed that the former was the only species in the Great Basin and Pacific Coast Areas and that the latter was confined to the States east of the Rocky Mountains. Later it was found that both occur in the West, and that the latter is increasing there.

These smuts possess a vile odor which affects the value of wheat and flour and makes the control of the disease imperative. They are chiefly responsible for the destructive grain-separator fires in the Pacific Northwest, fully discussed in the chapter on Agricultural Engineering. They likewise were one of the principal reasons for the nation-wide demonstration of the treatment of cereal seeds with chemicals during the World War. Widespread coöperative research has been conducted into methods of infection, seed treatments, and breeding for bunt resistance, by Federal and State agencies during many years.

Most of the coöperation began in about 1918, with the war-time campaign, and was continued in the form of research after the war. As this smut is especially destructive in the drier areas of the West, much of the work has been done in the Great Basin and Pacific Coast Areas, involving the California, Idaho, Oregon, Utah, and Washington Agricultural Experiment Stations. Minor studies have developed at the Minnesota, Montana, and North Dakota Stations on the second species named.

California Station: After the close of the State-wide wartime campaign to control cereal diseases, joint Federal-State research was started in 1918 to determine the cause of injury to wheat seeds apparently occasioned by formaldehyde treatments against smuts and other fungi (41—20:209). Investigation, showing that mechanical injury to seed coats in threshing was the primary problem (41—21:99), led to more careful adjustments of the separators.

In 1918, under the provisions of the coöperative agreement previously discussed under stem rust, coöperative research in cereal smuts was begun by the Federal Division of Cereal Crops and Diseases at the University of California Agricultural Experiment Station at Berkeley. A junior pathologist was transferred to Berkeley to begin the work. He was given office and laboratory space and stenographic service by the Agricultural College Division of Agronomy. Experiment plats and service, as well as any greenhouse space required, also were provided by this Division.

As the work developed, the production of improved varieties of the different cereals, resistant to one or another of the smuts affecting these crops, became a part of the program. The making of these hybrids, chiefly wheat, and the growing and selection of the resultant progenies, were done largely at the University Farm at Davis, where larger areas and equipment were available, and where co-operation in cereal production also was established in 1922. Certain phases of the treatments of cereal seeds with various chemicals to control smuts, and the growing of the crops from the treated seed, also were carried out at Davis. In 1926, the coöperating employee received an appointment from the University of California with the title of Associate in Agronomy.

For the first few years, major emphasis was placed on improved chemical treatments for infested seed supplies and on improved apparatus for making treatments. Some of these coöperative results were published by the State (8—364; 18—4:407) in 1923. Two papers, one covering tests of the toxicity of the treated grain to house mice, appeared in the private journal, *Phytopathology*, in 1926. In 1926 and 1927, the State Extension Service organized and operated a community combined seed-cleaning and seed-treating apparatus in San Luis Obispo County. The published discussion of such procedures was authored jointly by representatives of the Federal and State Extension Services, the Federal Division of Cereal Crops and Diseases, and the Grain Division of the Federal Bureau of Agricultural Economics (96—33), in 1929.

In about 1924 a comprehensive coöperative research was begun in the inheritance of bunt (*Tilletia tritici*) resistance in different varieties and hybrids of wheat, results of which were published at intervals (41—32:973, 40:225, 40:353, 42:307, and 44:121) from 1926 to 1932. A study of factors which modify resistance was issued (31—4:175) in 1929. Breeding wheats by the back-cross method was published in the *Journal of the American Society of Agronomy* (2—22:238) in 1930. A comprehensive bulletin (90—1299), in 1925, on the relative resistance of wheats to bunt in the Pacific Coast States included California data and a California author.

Great Basin and Pacific Northwest: In 1919, extensive and co-ordinated Federal-State studies were begun, in California, Ore-

gon, and Washington, of the relative resistance of wheat varieties to bunt infection. At that time it was thought that there was but one species of bunt (*Tilletia tritici*) in that area. Tri-State data were published (90—1299) in 1925. Later it was discovered that a second species (*T. levis*) had been introduced from the Midwest and was becoming increasingly abundant.

The Oregon Station published a general discussion of the bunt problem (78—188) in 1922, under coöperative authorship. At the Washington Station, the Divisions of Plant Pathology and Agricultural Engineering, in 1921—22, investigated apparatus and methods for dusting wheat to control bunt (142—171). The genetics of bunt resistance were studied collaboratively and published (41—23:445) in 1923. A summary of the literature on bunt and of knowledge regarding the disease was published coöperatively (90—1239 and 1276) in 1924. By this time the presence of the second species of bunt was becoming recognized, so that later researches included both species.

The inheritance of the reaction of wheat varieties to physiologic forms of both species was the subject of joint Federal-State inquiry at the Washington Station from 1929 onward, with results published at intervals (41—47:89). In the meantime, the critical problem of hybridization between the two species and the possible production of new physiologic forms also was investigated jointly (41—44:49). More extensive coöperative research in physiologic specialization, involving the Idaho, Oregon, and Washington Stations, was published (41—47:193) in 1933.

Minnesota, Montana, and North Dakota: In Minnesota, the co-operative wheat-breeding experiments included minor attention to obtaining resistance to the bunt species (*T. levis*) in the north-central States (41—48:31, 59). The Federal-State partnership included the two Station Divisions of Agronomy and Plant Pathology, and the second paper, issued in 1934, had a three-way authorship. In Montana, recent coöperative breeding studies included the inheritance of bunt reaction, among other characters, in Hope wheat crosses, the results being published (41—46:413) in 1933 under joint authorship. In North Dakota, collaborative investigations of the resistance of spring-wheat varieties were published (74—231) in 1929, under joint authorship.

Federal Interbureau coöperation: A publication on the prevention of bunt was issued (95—108) in 1928 by the Bureaus of Plant Industry (Cereal Crops and Diseases) and Extension Service (Coöperative Extension Work) and again in 1931 by these two and the Grain Division of the Bureau of Agricultural Economics (93—182).

Uniform breeding nurseries: In the recent program of breeding wheats to control bunt, three series of uniform bunt nurseries have been maintained in coöperation with the State stations. Those for hard red winter wheats are established on twelve stations and substations in Colorado, Kansas, Montana, Oklahoma, and Texas. Similar coöperative nurseries for testing spring wheats for bunt resistance are grown at nine points in Minnesota, Montana, North Dakota, South Dakota, and Washington. For the varied wheats of the western areas, nurseries are grown at twelve similar stations in Idaho, Montana, Oregon, Utah, and Washington. About fifty varieties, strains, and hybrids are included at each station.

Loose smut of wheat.—The loose smut of wheat (*Ustilago tritici*) is difficult of control because the accepted method of soaking the seed in hot water must be precisely used, as otherwise either the seeds may be injured or the fungus not killed. Such precision is difficult to obtain on the farm. Accordingly, in 1918, the Federal Division of Cereal Crops and Diseases entered into coöperation with the Federal-State Extension Service in Indiana, and particularly with the county agent in Shelby County, in the demonstration of a community treating plant. The demonstration was successful and many other plants were put into operation. Independent Federal research was continued to answer some of the questions arising from the new enterprise and the results were published (41—28:79) in 1924. Physiologic studies of wheat with relation to loose-smut infection followed (41—39:313 and 43:503) in 1929 and 1931. More recently, breeding investigations have been begun in coöperation with the Utah Station and results on the inheritance of the reaction to loose smut by certain crosses have been published (41—48:631) in 1934.

Flag smut of wheat.—The flag smut of wheat (*Urocystis tritici*) was not known to occur in the United States until 1919, when it was found in fields in Illinois. Studies were begun immediately in

the laboratories of the Federal Department and, in 1920, in coöperation with the Missouri Botanic Garden (41—27:425). Wheat varieties for the tests were furnished by many States. In the collaboration with the California Station on cereal diseases, a discussion of flag-smut and take-all quarantines was published in coöperation with the State Department of Agriculture (12—8:456) in 1919.

Coöperative studies were begun also in Illinois and several publications were issued (36—242 and 273; 35—242) from 1920 to 1923, in joint Federal-State authorship. The last-named bulletin was concerned with varietal resistance. The school board of Granite City, Illinois, granted the use of space in a high-school building for local experiments. The disease later was found in Missouri and Kansas and the Stations and Extension Services of those States assisted in the necessary surveys. Finally, through coöperation with the University of Sydney, Australia, studies of parasitism of this rust (41—27:451) were made in that country, where it long has been known.

Diseases caused by imperfect fungi.—There are numerous funguses belonging to several genres of the so-called imperfect fungi (*fungi imperfecti*) which affect cereals, including wheats. They cause different rots, molds, blights, scabs, and other maladies. Some of these organisms cause very different manifestations on the same crop at different stages in its development, or on different crops at the same or at different stages. The imperfect and perfect stages of the same fungus are quite different and the actual relations are established only with difficulty.

The whole subject has led to far-reaching Federal-State research under the Federal Plant Industry Division of Cereal Crops and Diseases, the collaboration being especially with the Wisconsin Station. Beginning in 1919, the early investigations covered the effects of dry heat as a treatment of cereal seeds against such organisms (41—18:379). At the same time an extensive study of the influence of soil temperature and moisture on infection of wheat seedlings by *Helminthosporium sativum* was conducted, involving coöperation with the Illinois Station, also, in the field studies (41—26:195).

In 1925, a comprehensive discussion of the foot-rot diseases of wheat in America, made in coöperation with the Illinois, Kansas,

North Carolina, Oregon, Washington, and Wisconsin Stations, was published by the Federal Department (90—1347). Beginning in 1929, a study was made of the *Cercospora* foot rot of winter wheat, in coöperation with the Idaho, Oregon, and Washington Stations, and the results published in 1934 in a Department *Technical Bulletin* (92—428).

In 1925, a conference of specialists in this group of organisms was held at the Wisconsin Station and from it developed a research coöperative with the Tennessee and Wisconsin Stations in the fundamentals for taxonomic studies of the complex and numerous species of the genus *Fusarium* (41—30:833). Thereafter there was continuing formal and informal coöperation between the Federal Divisions of Cereal Crops and Diseases and Mycology and Plant Disease Survey in taxonomic studies of these and allied organisms.

Foot rot or scab: No better example of a single fungus manifesting itself in several different ways can be found than the one (*Gibberella saubinetii*) which in its imperfect and perfect stages causes root rot, seedling blight, and head scab in wheat, and root, stalk, and ear rots in maize. The proof of this intercrop parasitism was the result of coöperative research in wheat diseases at Wisconsin Station and in maize diseases at the Indiana Station (41—14:611), published in 1918. Intensive research on the wheat aspects was continued at Wisconsin and a general account of this fusarium blight or scab (41—20:1), and accounts of the production of conidia (41—19:235), the influence of soil temperature and moisture (41—23:837), and the relation of crop successions (41—27:861), all were published from 1920 to 1924. The last named included coöperation with the Funk Brothers Seed Company of Bloomington, Illinois, and the Illinois Station and had joint authorship. A general discussion of foot rots of wheat based on Federal Department coöperation with the Illinois, Kansas, North Carolina, Oregon, and Washington Stations as well as with the Wisconsin Station appeared (90—1347) in 1925. Later coöperative investigation in Wisconsin included a cytological study of the relation of the semi-permeable membranes of the wheat kernel to infection (41—45:609), and of the factors of infection of wheat heads (41—46:771), with publication in 1932 and 1933. Much closely related research is discussed under maize.

Take-all or foot rot: One of the imperfect fungi (*Ophiobolus graminis*), of Old World origin, was first recognized in the United States in Virginia in 1919 and in many States soon thereafter. It causes a seedling rot of wheat and also may appear as a head blight. The appropriate name, take-all, was given to it in Australia.

In connection with the Federal-State coöperation on cereal diseases at the California Station, a discussion of quarantines against take-all and flag smut was published in coöperation with the State Department of Agriculture (12—8:456) in 1919. The first coöperative study involving take-all was a general investigation of foot-rot diseases of wheat (90—1347) by the Illinois, Kansas, North Carolina, Oregon, Washington, and Wisconsin Stations and the Federal Department.

This preliminary study was followed by extensive coöperative research developed at the Wisconsin Station. Most of it has been in the environmental conditions affecting growth and infection. Among the pertinent matters studied were air temperature, light, hydrogen-ion concentration, and overwintering (41—31:801), soil temperature and moisture (41—31:827), and hydrogen-ion concentration again (41—33:845), all published in 1925 and 1926.

In about 1925, Federal coöperation was begun with the Kansas Station and additional environmental studies were made. Among these were the influence of oxygen and carbon dioxide (41—37:349) and morphological and microchemical conditions and effects within the wheat plant (41—37:647), both being published in 1928. Studies of the infecting power of the fungus at different levels in the soil were published (41—49:871) in 1934.

Rosette and mosaic disease.—The name rosette disease was given to a dwarfing disease of wheat first reported from Madison County, Illinois, in 1919. Initial Federal Department investigations, conducted in coöperation with the Wisconsin, Illinois, and Indiana Stations, the Missouri Botanical Garden, and the Granite City, Illinois, school board, were published (41—23:771) in 1923. Tests of the resistance of two hundred wheat varieties were conducted in coöperation with the two States last named (41—26:261) and reported under joint authorship. With the Wisconsin and Illinois Stations, critical studies were made of the intracellular bodies associated with the rosette disease and of a mosaic mottling of wheat

leaves, both reported under joint authorship (41—26:605) in 1923. The same coöperation produced two general summaries of knowledge regarding mosaic and rosette, one Federal (90—1361) and one by Illinois (35—264), both in 1925 and under joint authorship.

Thereafter the Federal coöperation continued only with the Wisconsin Station. Two papers on soil factors of the development of the mosaic disease in winter wheat (41—35:587 and 36:53) appeared in 1927 and 1928. A third on transmissibility to other cereals (41—40:547) was issued in 1930. Results of a seven-year coöperative research in virus properties and techniques were issued (41—35:1 and 35:13) in 1927.

Insect pests.—There has been relatively little Federal-State co-operation in research into insect pests of wheat through the years, chiefly because of the noncoöperative organization of the former Federal Bureau of Entomology. As noted, however, under the discussion of general cereal protection, the Bureau studies of the Hessian fly in California (92—81) acknowledged assistance received from the California Station entomologists. In Kansas, the State Station and the Federal Division of Cereal Crops and Diseases conducted coöperative investigations of the resistance of winter wheats to Hessian-fly injury (43—27), the results being published in 1931. Within individual State stations there often is coöperation between two or more divisions in such studies.

Nematode injury.—Nematodes or nemas are minute or microscopic worms, one species of which infects cereals, especially wheat (90—842). Several outbreaks have occurred during the past two decades in the Appalachian States of Maryland, Virginia, and Georgia. The Plant Industry Division of Cereal Crops and Diseases has determined the life history of the nematode and, in coöperation with workers from the State stations and extension services involved, has developed methods of cleaning the infested seed supplies and starving the nemas in the soil of the infested fields through proper rotations of crops. Research in temperature effects and overwintering of the nemas was conducted in coöperation with the Wisconsin Station (41—27:925) in 1924. The Bureaus of Plant Industry and Markets coöperated in a study, published in 1918, of nematode galls as a factor of loss in marketing and milling wheat (90—734).

Climatic and soil influences.—The principal harmful effect of climate on wheat is cold injury. This problem has been attacked chiefly through breeding for cold resistance in winter wheats, chiefly the hard red winter varieties. Most of the coöperative production investigations of this group of wheats, discussed above, have included comparisons of winter hardiness and the results of breeding carried on to obtain it. Special compilations of coöperative data have been made recently by the Federal agency. Comparative hardiness of winter-wheat varieties (94—378) was published in 1926, and data on hardiness and yield (93—141) in 1930. The latter covered experiments conducted for some or all of the years from 1920 to 1929 on thirty stations in the United States and Canada, thus marking international coöperation. Laboratory studies with a special freezing apparatus, the Federal Department coöperating with the Minnesota Station, were published (41—35) in 1927. The results of extensive experiments in breeding for winter hardiness and yield, during 1921—28, in coöperation with the Colorado, Kansas, Minnesota, Montana, Nebraska, and North Dakota Stations, were made known in 1929 in a Department *Technical Bulletin* (92—136).

Investigations of furrow drilling, or seeding in unusually deep drill furrows, were mentioned briefly under General Cereal Protection. This practice is designed to bring more protection through accumulating deeper snow cover and through preventing soil particles, drifting on level fields, from cutting seedlings off at the soil line. Special studies made in Federal-State coöperation have been published by the Kansas (43—13) and Montana Stations (60—177) in 1924 and 1925, respectively.

In 1920, the Bureaus of Chemistry and Plant Industry published, under joint authorship, a study of the effect of lime on the sodium-chloride tolerance of wheat seedlings (41—18:347).

The publications listed in the Literature Cited at the end of this chapter which have been cited in these subsections on Introduction, General Cereal Activities, and Wheat in the section on Cereal Crops are Nos. 2, 8, 12, 18, 19, 31, 35, 36, 40, 41, 42, 43, 55, 56, 60, 63, 64, 71, 74, 78, 81, 86, 90, 91, 92, 93, 94, 95, 96, 97, 105, 121, 130, 136, 142, 146, and 148.

WHEAT ALLIES AND RYE

These crops are relatively much more important in Europe than in America, where only rye has any statistical position.

Wheat Allies

The minor cereal crops and feeding grains, emmer, spelt, and einkorn, are known as wheat allies because they are closely related to wheat. Although used as cereals in the Old World, they are but little grown here and then mostly for feeding purposes. Some varieties, especially Black Winter emmer, were widely tested on the dry lands of the West from the early nineties onward and the coöperative results included in the general cereal publications hitherto noted. These results, as summarized by the Federal agency and published (90—1197) in 1924, contain data from three years of coöperative experiments with emmer and spelt at Modesto, California. The South Dakota Station published its coöperative data (86—179) in 1918.

Rye

Rye has been tested as a grain and green manure crop in many of the coöperative investigations with cereals, and results will be found in many of the publications noted under general cereal production. Coöperative studies of rye production in Georgia were published in 1917 by the State Extension Service. Most of the rye breeding has been independently conducted. Plant Industry interdivisional coöperation by Plant Physiological Investigations and Cereal Investigations covered physiological and biochemical studies of the ungerminated rye kernel (41—30:989) in 1925.

There has been more Federal-State coöperation in the protection of rye from diseases. At the Minnesota Station, the variety of stem rust which attacks rye was investigated from 1918 onward, and data on rye are included in many of the papers on physiological specialization cited in the discussion of wheat protection from stem rust. A special study of such specialization in the stem rust of rye was published (41—45:297) in 1932.

In the coöperative research in leaf rusts at the Indiana Station, a preliminary study of rye varieties and strains with reference to resistance to leaf rust was published (41—25:243) in 1923. Fur-

ther research covered the resistance of rye to stem rust, leaf rust, and powdery mildew (41—32:201), published in 1926. The aecial stages of the leaf rusts of rye and barley were determined in the Indiana coöperation and published (41—28:1119) in 1924.

Research into the infection of rye by the bunt or stinking smut of wheat was conducted coöperatively with the Washington Station and published (81—13:210) in 1923. In the coöperation (*i.e.*, Federal-State again) with the Wisconsin and Illinois Stations on the study of wheat mosaic, winter rye was included (90—1361). Finally, a bacterial blight of rye was investigated with the Wisconsin Station (41—28:1039) and published in 1924.

BARLEY

Barley is grown partly for brewing and partly for feed. With the advent of national prohibition, many predicted disaster for the barley growers of America. However, although the acreage at first decreased, it soon began to rise and presently had almost doubled the pre-prohibition figure. As the barley now was being grown for feeding purposes, the acreage was more widely distributed than before.

Production and Improvement

Coöperative experiments with barley, like those with wheat, have been both domestic and international in scope and will be discussed in that order.

Investigations in the United States.—Most of the coöperative experiments which already have been discussed under Rotation and Tillage, and General Cereal Production, have included barley among the cereals. Those investigations of which the barley results were published separately are recorded here. Mostly, they are from States of the Great Plains, such as Colorado (19—371), Montana (60—209), North Dakota (74—184), South Dakota (86—183), and Wyoming (148—185). Recently established Federal coöperation with the Utah Station has resulted in a bulletin (136—261) issued in 1935.

Minor research in the genetics of the barley spike was begun by the Federal Division of Cereal Crops and Diseases in coöperation with the Minnesota Station in 1915. Distinctions with reference to use in breeding (90—137) were published in 1914. Inheritance

of internode length was published (90—869) in 1920, with a statement of the coöperation. Another contribution was published (41—19:575) in the same year.

The barley introductions from abroad, mentioned below under International Investigations, have been grown under quarantine on a secluded station in Arizona under coöperative agreements between two Divisions of the Bureau of Plant Industry and the Office of Indian Affairs in the Interior Department. The coöperative relation has been continued there because it was found that plants could be grown as a winter crop, hybridized in early spring, and the seed matured in time for summer sowing at the coöperating Aberdeen Substation in Idaho, where a second crop could be grown in the same year, thus speeding up the breeding program.

The Federal-State coöperation in barley production at the Idaho Station began in about 1913, and included varietal tests, breeding studies, and physiological and chemical research on the development of the barley kernel. This latter investigation, conducted between 1915 and 1920, covered the norm of daily development (41—19:393), development in clipped and unclipped spikes (41—19:431), effect of time of irrigation (41—21:29), water content (41—23:333), and development of immature kernels removed from the plants (41—36:669), all published between 1920 and 1926.

International investigations.—In 1923 the barley specialist of the Plant Industry Division of Cereal Crops and Diseases was sent by the Federal Government to the Mediterranean region and the Punjab of India to search for primitive forms of barley for breeding purposes. This project involved not only active coöperation between the U. S. Departments of Agriculture and State, but also coöperation with the British, French, Egyptian, and Ethiopian governments. Some highly interesting primitive varieties were found in the highlands of Ethiopia, through the courtesies extended by that Government.

In 1921, an unusual and extensive international coöperation was arranged to provide for the compilation and interpretation of all varietal experiments with barley conducted in the United States and Canada. The first compilation (90—1334) contains all varietal comparisons in the years to and including 1921 for which records

could be found. It involved the U. S. Department of Agriculture, the State experiment stations in this country, and the Canadian Department of Agriculture. These agencies made available all their data, whether obtained independently or coöperatively, and whether published or unpublished. Data were obtained from all the Federal stations, from all the States except one, and from most of the numerous Dominion-operated stations in Canada. The second compilation (92—96) covered the five years from 1922 to 1926 and contained data from all the States and from both Dominion and Provincial stations in Canada. It also has one Dominion author. It involved the coöperation of the Provincial colleges of agriculture as well as of Dominion authorities. A third compilation (92—446), for 1927—31, has the same scope and international authorship as the second. In all three publications a general statement of coöperation appears in the introduction, while specific relations are shown with the data from each station.

Protection

Barley is subject to attack by rusts, smuts, and other fungus diseases, especially scab (*Gibberella saubinetii*), which sometimes renders it unfit for feeding purposes. As the result of a severe outbreak of scab in the late twenties which caused international complications over export feeding barley, the Federal Bureaus of Agricultural Economics, Animal Industry, and Plant Industry, the latter in coöperation also with the Wisconsin Station, made a joint study of the situation and its various factors. Later research, published in 1935, covered the variability of pathogenicity and cultural characters of this organism (the scab fungus), which causes also a seedling blight (41—51:145). Collaboration at the Wisconsin Station also covered other diseases caused by imperfect fungi, including barley stripe, published upon (92—341) in 1932 under joint authorship.

In coöperation with the Indiana Experiment Station, the Bureau of Plant Industry determined the aecial stages of the leaf rusts of barley and rye and published (41—28:1119) in 1924. Then they studied the susceptibility of barleys to leaf rust and powdery mildew, published (92—295) under joint authorship. More recently, some of these leaf-rust studies on barley have been made at the

Kansas Station also (81—26 :235). Within the Indiana Station itself, the Departments of Agronomy, Botany, and Dairy Husbandry coöperated in a study of enzymes produced by the scab fungus, and published (41—43 :223) in 1931. At the Minnesota Station, the Federal Division of Barberry Eradication coöperated in a study of the genetic reaction of barleys to stem-rust infection and also to the barbing of their awns (41—46 :1121).

In California, soon after the beginning of coöperation in cereal diseases in 1918, a study was made of barley diseases caused by imperfect fungi (8—511), especially *Helminthosporium* and *Rhynchosporium* species. Later, some studies were made of factors influencing infection by barley smut (41—35 :907), including dehulling with acid.

OAT

The oat crop is gradually diminishing in area, owing to the steady displacement of horses and mules by tractors and trucks. Nevertheless, coöperative research into oat production and improvement, and into the protection of oat from disease, continues on a large scale.

Production and Improvement

Independent Federal breeding studies on oat began (90—99) in 1902, and Federal-State coöperative investigations of growing and bettering the crop date from 1903 in Iowa (90—99) and South Dakota (90—39). Gradually these were extended to all parts of the country in the next ten years. Some of the compilations covered wide areas but most of the coöperative experiments were with the individual State stations.

The Federal Office of Cereal Investigations compiled, in 1910, all available Federal and State data on Swedish Select oat from all experiments, coöperative or independent, in this country (121—182). In 1920, it published the same type of data for the two closely related Russian varieties, Kherson and Sixty-Day (90—823), to the end of 1917, from a large number of stations throughout the country.

With the added emphasis on breeding operations about ten years ago, the Federal Division of Cereal Crops and Diseases took the lead in establishing a coördinated series of oat-breeding nurseries

in about 1925 and oat winter-hardiness nurseries in 1926. According to a comprehensive mimeographed publication (74 pp.) of the results by the Division in 1935, the breeding nurseries were located at some sixty-four stations in thirty States and the hardiness nurseries at about twenty-five stations in eleven States. Nearly all of both were in Federal-State coöperation.

Eastern States.—Iowa Station: Informal Federal-State coöperation in oat investigations began in Iowa in 1903, formal coöperation in 1905, and the Iowa Station was made the headquarters for the Corn Belt oat-improvement studies (90—99) in 1909. The results of extensive comparisons of northern varieties and hybrids at the Iowa and New York (Cornell) Stations, with some data from other stations, were published (90—99) in 1914, under three-way authorship. In 1925, the Federal agency published (90—1343) a discussion and description of new and improved varieties for the Corn Belt, developed coöperatively at the Iowa Station, also under joint authorship. *Department Bulletins* of this period showed the scope of coöperation prominently in a box on the front cover.

A bulletin containing similar data was issued by the Iowa Station (39—227) in the same year. Two earlier State bulletins (39—128 and 175), published in 1912 and 1918 respectively, had contained progress reports on the coöperative experiments and displayed the statement of coöperation on the front cover. A fourth bulletin (39—247), appearing in 1928, gave data on Iogold, another new variety developed collaboratively. Extensive coöperation in the protection of oat from diseases will be discussed under Protection.

Cornell (N. Y.) Station: Official Federal-State coöperation in oat-breeding investigations at the Cornell University (N. Y.) Station began in 1907 (90—99) and continues. Cornell Station coöperative data were included in three Federal publications (90—99, 823, and 1343) previously mentioned, beginning in 1914. In the same year the State published a progress report on the work (70—343), with a title-page statement of the coöperation. In the early part of the coöperative program, some work was done on the biometrical constants in oat, and the results were published (71—3 and 4) by the station, also in 1914.

In 1925, the Federal Division of Cereal Crops and Diseases pub-

lished, under joint authorship, a discussion and description of new and improved varieties developed in the coöperation (94—353), giving the results of station studies and of farmer tests throughout the State. In the same year, the Cornell Station published much the same data (70—436), also under joint authorship. These last-named publications both had the coöperation prominently stated on the covers.

Southern red oats.—In the Southern States, Federal-State oat-improvement studies have been conducted with the Georgia and Tennessee Stations over many years. Some early work was done at the Maryland Station, and recently formal coöperation has been effected with the Texas Station at the Denton Cereal Substation in northeastern Texas. Not all of the oats grown in the South belong to the red oat group (*Avena byzantina*) but these are the prevailing varieties. In the deep South they are sown as winter oats, while farther north, and extending into the southern section of the Great Plains, they are used as spring-oat varieties.

In Georgia, the results of coöperative experiments begun in 1914 were published by the State Extension Service (27—113) in 1916. The Federal agency compiled data from many stations on Fulghum, one of the improved red varieties, and published them (94—193) in 1921, including coöperative results from the Georgia State College of Agriculture and the Kansas and Missouri Stations. Coöperation with the Georgia College was continued, and in 1927 a Federal publication assembled all available data on fall-sown oats from this and other stations (90—1481) to the end of 1925, under joint authorship and with a prominent cover-box recognition of the coöperation.

At the Kansas Station, coöperative breeding investigations on red oats resulted in the isolation of a valuable variety, Kanota, reported (44—91) in 1921. A critical and comprehensive research into variability in the Burt oat, a red spring variety, also conducted in coöperation with the Kansas Station, was published (41—30:1-64) in 1925.

The Great Plains Area.—The Federal-State coöperation in oat production in the Great Plains Area was concerned with white or yellow oats, except from Kansas southward. The experiments, beginning in South Dakota in 1904, have been published mostly in

the cereal bulletins cited under Cereal Production. Several States, however, have published oat data separately: Colorado (19—370), which summarized many years of results under joint authorship; Montana (60—209); South Dakota (86—110 and 149) in 1908 and 1914; and Wyoming (148—181). Kansas and Texas coöperative studies of red oats have been noted above.

Great Basin and Pacific Coast Areas.—*California Station:* Minor experiments were conducted in California with oats in the Federal-State formal coöperation begun in 1904 and continued informally from 1906 to 1910, as described under Wheat Production (8—216; 121—178). Since 1922, cereal experiments have been coöperative at the station at Davis, and the State recently has published the oat data (8—467). The varietal comparisons made in different sections of the State were conducted in coöperation with county farm advisors of the Extension Service. Research in the inheritance of floret separation and other characters was published (41—43:365) in 1931.

Other western States: Most of the results of coöperative oat-production experiments in Idaho, Oregon, Utah, and Washington have been presented in the bulletins on General Cereal Production, already cited. Recently expanded coöperation in Utah has resulted in publication of results from all stations and substations for the years 1931 to 1933 (136—260). Some critical breeding studies at the Washington Station will be reported under Protection, as they were directed toward smut resistance.

Protection

Protection of the oat crop comprises studies of the organisms causing rusts, smuts, and other diseases, and includes seed treatments to eliminate infection, physiologic specialization of the fungus, influence and eradication of the alternate host of crown rust, breeding for resistance, determination of its inheritance, and tests of the strains created, as well as furrow-drilling practices to prevent or lessen winter injury. Some of the previously cited experiments on cereals, conducted in Georgia and Kansas, contain data on furrow drilling of oats (43—13; 92—14).

Stem rust and crown rust.—Stem rust of oats (*Puccinia tritici avenae*) has been investigated in Federal-State coöperation pri-

marily at the Minnesota Station but to some extent at the Iowa and California Stations also. The Minnesota research into physiologic specialization of the stem-rust fungus covered all physiologic varieties, including that on oats. The publications previously cited on stem-rust specialization under Protection of Wheat therefore contain data on the oat variety of stem rust also. One special co-operative study of this rust variety was published (41—24:1013) in 1924. A comprehensive summary of the rust resistance of oat varieties and strains grown between 1923 and 1927 in sixty-five nurseries widely distributed in the United States and eastern Canada has been published (92—143). While based primarily on co-operation with the Minnesota Station, it involved minor coöperation by many State and Canadian stations in growing the plants and helping to interpret the results.

Breeding oats for stem-rust resistance has been conducted in Federal-State coöperation with the Iowa Station (40—62), including studies of the inheritance of resistance (41—37:1). In coöperation with the California Station, also, the stem-rust resistance of oat varieties was tested (41—28:705) and published in 1924.

Coöperative Federal-State research in crown rust of oats has been centered at the Iowa Station since 1914. Data resulting from this coöperation have been published on factors affecting the development of the rust spores (40—49), alternate hosts and physiologic specialization (40—49 and 72), the rôle of the genus *Rhamnus* in spreading crown rust (90—1162), the alternate hosts of crown rust (41—35:953), and methods of eradicating susceptible *Rhamnus* (93—133), all published between 1919 and 1930. A very recent paper on physiologic specialization appeared (92—433) in 1935.

Coöperative studies of the comparative resistance of oat varieties to crown rust were published (40—62) in 1920. More recent studies on the effect of crown-rust infection on yield and water requirements of oat appeared (41—50:387) in 1935, and in 1936 on the effect of the same disease on the composition of oat (81—26:220).

At the California Station, a cytological study of heterothallism in this rust (41—45:513) has been made as part of cytologic re-

search on cereal rusts, coöperative between the Federal Division of Cereal Crops and Diseases and the Station Divisions of Agronomy, Genetics, and Plant Pathology.

Covered and loose smuts.—Two different smuts, covered (*Ustilago levis*) and loose (*U. avenae*), are destructive to the oat crop. Both are controllable by seed treatments. The nation-wide campaign for the treatment of cereal seeds during the World War, sponsored coöperatively by the U. S. Department of Agriculture, the Federal and State Food Administrators, and the State colleges of agriculture, included the treatment of oat seeds against these smuts. This campaign was followed, at the Wisconsin Station, by coöperative research into the relation of soil conditions to infection by loose smut (41—24:569) and into the influence of various conditions on spore germination in the same smut (41—24:577). More recently, research in breeding for resistance and in physiologic specialization of the fungus has become increasingly important.

In 1925, Federal-State data on the resistance and susceptibility of many oat strains to both smuts, based on experiments coöperative with the Idaho, Iowa, Kansas, Missouri, and Washington Stations, and the Brooklyn Botanic Garden, were published (90—1275). Coöperative Idaho data on susceptibility of hybrid selections were issued (41—30:375) in the same year.

In 1925 to 1927, Federal-State data were obtained on the resistance of hybrid oat selections to both loose and covered smut, in coöperation with the Idaho, Iowa, Montana, North Dakota, and Oregon Stations. The data on the influence of dehulling on infection by covered smut were issued (41—41:621) in 1930, and the detailed data on the inheritance of resistance to this smut appeared (41—43:1085) in 1931. The results from the studies of resistance to both smuts were published together (92—422) in 1934.

Federal-State coöperation at the Oregon and Washington Stations, with minor assistance from other States, resulted in the development of the Markton variety, immune from covered smut (94—324), published under three-way authorship in 1924. Federal coöperation, continued with the Brooklyn Botanic Garden, covered research into physiologic specialization in both smuts (on red oats), published (41—44:147) in 1932, and studies of the inherit-

ance of resistance of oat hybrids to both smuts (41—48:107), published in 1934.

Miscellaneous diseases.—Studies of halo blight, a bacterial disease of oats (41—19:139), were made in coöperation with the Wisconsin Station before 1920. Further coöperative studies of oat sterility were published (90—1058) in 1924.

RICE

Rice production began in the coastal areas of the South Atlantic States in early Colonial times and was continued there actively until the Civil War. About a hundred years ago, production began in the Gulf States and increased rapidly on the lower reaches of the Mississippi River after the Civil War. In about 1887, large-scale production was found profitable on the fertile prairies of southern Louisiana and gradually spread to Texas and Arkansas, and even to Missouri and Illinois. The growing of Japanese rice in California dates commercially from about 1912.

As production increased and extended into new areas, various problems arose and the State and Federal governments were asked for assistance in their solution. Much of the investigation conducted has been coöperative between Federal and State agencies. The present Division of Cereal Crops and Diseases in the Federal Bureau of Plant Industry and the divisions of agronomy and plant pathology of several State agricultural experiment stations are the agencies involved, either independently or in coöperation. The coöperative experiments in California, Missouri, and Texas have been chiefly in rice production and improvement, and those in Louisiana have covered both production and protection from disease, whereas those in Arkansas have been chiefly concerned with disease control.

Production and Improvement

Investigations of methods of production and improvement of rice have been conducted in three important rice-producing States—Louisiana, Texas, and California—with minor studies in Missouri. The eastern and western areas are very different and are discussed separately. Plant Industry interdivisional coöperation by Plant Physiology and Cereal Crops and Diseases resulted in a study of the nitrogen compounds of the rice kernel (41—34:309). Federal

interbureau coöperation of Agricultural Economics and Agricultural Engineering in a study of artificial drying of rice on the farm was published (93—292) in 1933.

Lower Mississippi Valley.—Coöperative experiments have been confined to three States, Louisiana, Texas, and Missouri, the investigations in Arkansas being concerned with diseases.

Louisiana Station: Federal-State coöperation in rice investigations began with the establishment of the Crowley Rice Experiment Station in Louisiana in 1909, under joint Federal-State auspices (46—172; 90—1356). The relation has been maintained since that year. In the early years, however, the various lines of work on the station were divided between the two coöperating agencies, one being charged with certain specific fields of study and the other with an entirely different group. This, a most unusual arrangement, was due largely to the personalities of certain administrators rather than to the application of any accepted principle in such relations. In later years, all the experiments were conducted in actual coöperation, as at other stations.

In 1920, the State presented the results obtained (46—172). The Federal agency published on the new rice varieties developed or imported (90—1127) in 1923, and on studies of production methods (90—1356) in 1925. Recent data have been presented in biennial reports of the Crowley Rice Station for the bienniums, 1928—29 (46—205), 1930—31, and 1933—34, the last two not in the bulletin series. The first does not mention the Federal coöperation, the second states it in the text, and the third shows it on cover and in text. A general discussion of rice growing and use, prepared by the Federal-State representative, was published by the Louisiana State Department of Agriculture and Immigration in 1934. Station interdivisional coöperation in testing the feeding value of rice by-products was published (46—242) in 1933. Other Louisiana coöperation will be discussed under Rice Protection.

Texas Station: The Rice Experiment Station was established at Beaumont, Texas, in 1909, jointly by the Federal and State-Station agencies. The coöperation was discontinued in about 1918, owing to personalities involved, but was renewed in 1931. A summary of station data on rice varieties for the period 1914 to 1932 was published (88—485) in 1933. The quality of varieties grown

in 1931 and 1932 was determined by the Federal-State Rice-Grading Laboratory at Beaumont.

Missouri Station: A few years ago the Missouri Station and the Federal Bureau of Plant Industry jointly established a small rice station near Elsberry, Missouri, and maintained it coöperatively until reduced budgets in the depression eliminated it.

California coöperative rice experiments.—In 1907, a present member of the staff of the California Station, then in the service of the Federal Bureau of Soils, and with previous experience in growing rice in Turkestan, made some minor tests on ranches in the Sacramento and San Joaquin Valleys. In 1908, he started experiments on a ranch near Biggs, and also, in company with a representative of the Federal Bureau of Plant Industry, made a reconnaissance survey of rice-growing possibilities in California. Experiments with ranchers were continued on an increasing scale by these officials during 1909, 1910, and 1911.

In 1912, the Sacramento Valley Grain Association, composed of a group of California farmers and business men interested in rice growing, was formed to coöperate with the U. S. Department of Agriculture in establishing an experiment station for rice investigations. A tract of some fifty-seven acres, near Biggs, Butte County, was obtained by them, equipped with the necessary buildings, etc., and turned over to the U. S. Department of Agriculture for use (90—1155). The experiments were begun in 1913, and the station still is being operated. Water needed for irrigation is furnished by the Sutter-Butte Canal Company.

The coöperative agreement between the Bureau of Plant Industry and the Sacramento Valley Grain Association provides that the association will furnish the land, buildings, teams, machinery, and other equipment, and keep them in repair. The land is held under a long-time lease, subject to Federal option of renewal. The Bureau of Plant Industry obligates itself to conduct the necessary experiments in rice production, improvement, irrigation methods, weed control, etc., and to furnish the technical personnel required. The Bureau is entitled to such quantities of the rice produced as are needed for continued experiments, or to exchange with other rice-growing stations. The surplus above these requirements goes to the Grain Association for sale, the proceeds being held for use

at the station for repairs, new buildings and equipment, and the employment of labor.

The first Federal-State coöperation in rice investigations in California was on methods of irrigation. In 1914, the California Station Division of Irrigation Investigations, already in coöperation with the Federal Division of Irrigation Investigations, entered into coöperation with the Division of Cereal Investigations in studies of rice irrigation at the Biggs Rice Station. In 1916 the coöperation was extended to include the State Department of Engineering and the State Water Commission and studies were made of the duty of water on eighteen rice farms in the Sacramento Valley. Results of both series of experiments were published (8—279) in 1917. The coöperation was continued and a second bulletin (8—325) presented the data for the years 1914 to 1919, inclusive.

In 1922, an informal coöperative understanding was reached between the California Station and the Federal Bureau by which the work on the two independent stations was closely coördinated. This resulted in a joint publication (8—375), giving some data from both stations for 1922 and 1923.

In 1925, formal coöperation was effected with the California Station, the Division of Irrigation Investigations being the collaborating unit. Under the agreement, the State, which was conducting independent rice experiments on an experiment plot at Cortena, on the west side of the Sacramento River, made its investigations at that tract completely coöperative with the Federal agency. The latter, in turn, made its experiments at the Biggs Rice Station completely coöperative with the State. This agreement is still in force. It provides for the coöperative use by either party of the data obtained at either station, with proper credit given to the other party in publications and correspondence.

The State Station promptly created an advisory committee on rice experiments. It was headed by the chief of the Division of Irrigation Investigations at the Station and included representatives of the Divisions of Agronomy, Plant Nutrition, Plant Pathology, Soil Technology, Farm Management, and Agricultural Engineering, as well as the superintendent of the Biggs Rice Station.

The major results obtained at the Biggs Rice Station while in coöperation only with the Sacramento Valley Grain Association

were published (90—688, 1155, and 1387) at intervals from 1915 to 1926. The publication issued in informal coöperation with the State station during 1923–24 has been mentioned (8—375). The results published since formal coöperation began in 1925 fall into two chief classes, those concerned with breeding and those on physiology. The State published a summary of experiments (8—454) from 1922 to 1927. Numerous publications on inheritance of various characters have appeared at intervals from 1927 onward in the *Journal of Agricultural Research* (41—36:581, 40:1105, and 47:771) and in the *Journal of the American Society of Agronomy*. Papers on physiology of the rice plant have appeared mostly in the latter journal. All have shown the Federal-State coöperation by means of footnotes. One recent study on the inheritance of earliness and of length of kernel represented Federal coöperation with the California, Arkansas, and Texas Stations.

Protection from Environmental Influences

The coöperative research has covered fungus diseases, harmful insects, and injurious cropping conditions or field practices.

Fungus diseases and field practices.—*South Carolina Station:* In 1904 and 1905, a Federal-State study of blast of rice was made in South Carolina. While the causal organism was not discovered, the conditions favorable to the disease were warned against (84—121).

Louisiana Station: In 1919 and 1920, research was made into two *Sclerotium* diseases causing seedling blights or stem rots (41—21:640). During the same period, studies were conducted on seedling blights and stack-burn caused, apparently, by several organisms (90—1116) and controllable by hot-water treatments. The straighthead disease, investigated at the same time (91—1212), was found to be caused by improper field practices.

In 1929, the coöperative investigation of rice diseases, begun in Arkansas in 1928, was extended to Louisiana and Texas. Progress reports of the Louisiana studies have appeared in recent biennial reports of the Rice Experiment Station at Crowley, with a statement by the director in the foreword, and some resulting researches have been published (41—47:675 and 50:81).

Arkansas Station: In 1928 a Federal-State coöperative study of

rice diseases (4—312) was started in Arkansas, especially at the Rice Branch Station. Several researches have been published from 1933 onward, including a comprehensive study of a stem rot (4—295) which was discussed briefly from Louisiana ten years earlier. Most of these papers (41—46:799, 47:675, 50:81, and 51:341) were concerned with different imperfect fungi. The researches presented in the second and third papers were conducted in coöperation with the Louisiana and Texas Stations also.

Insects and birds.—In about 1927, the Federal Bureau of Entomology entered into coöperation with the Louisiana Station and put a representative at the Rice Experiment Station to study the insects of rice and soybean (46—205). Progress reports of the investigations have appeared in the successive biennial reports of the rice station, with a foreword acknowledgment, by the director, of the coöperation. The investigation of the rice water weevil was published (46—214) with cover and text indications of the coöperation.

Blackbirds having become destructive in rice fields in Yuba County, California, in about 1930 and 1931, the Federal Bureau of Biological Survey and the Yuba County agricultural commissioner coöperated in a study of control measures (12—20:406).

The publications listed in the Literature Cited at the end of this chapter which have been cited in these subsections on Wheat Allies and Rye, Barley, Oats, and Rice, are Nos. 4, 8, 12, 19, 27, 39, 40, 41, 43, 44, 46, 60, 70, 71, 74, 81, 84, 86, 88, 90, 91, 92, 93, 94, 121, 136, and 148.

MAIZE

The Federal-State and Federal interbureau and interdivisional coöperation in maize production and protection is relatively recent. This is because the former Office of Corn Investigations, started as a section before the formation of the Bureau of Plant Industry in 1901, was extremely noncoöperative. After it was merged in the Division of Cereal Crops and Diseases in 1919, a coöperative program of corn production and improvement was begun, to match the program of protection already in progress. So intense and extensive has been the coöperative research in both fields that an unusually large volume of publication has resulted.

Production and Improvement

The major activities, since the belated beginning of coöperation, have been in corn breeding by self-fertilization and especially in the new enterprise of developing methods for producing first-generation crosses for field use. Previous work had been along the lines of methods of growing, maize judging, and ear-to-row breeding. These major improvement practices were reviewed in the light of newer knowledge (2—14:1 and 17:313) in 1922 and 1925, and again (90—1489) in 1927. The occurrence of certain proteins in the maize kernel was investigated through coöperation of the Federal Division of Plant Physiology (41—30:587) in 1925.

After the merging of Corn Investigations with Cereal Investigations in 1919, coöperation was begun with the Louisiana and Tennessee Stations in the South, and the Iowa, Kansas, Missouri, Nebraska, and Ohio Stations in the Corn Belt. The far-reaching coöperative activities at the Illinois and Indiana Stations on maize diseases were increasingly directed toward breeding for resistance to various environmental influences. Minor studies were made at a few other stations, including cytological research in coöperation with the Department of Botany at Cornell University, New York.

In 1924, the Federal Division of Cereal Crops and Diseases issued a *Department Circular* on the handling of soft-corn crops (94—333), based on information furnished by the Illinois, Iowa, Minnesota, and Nebraska Stations and the Federal Bureaus of Plant Industry, Animal Industry, and Agricultural Economics.

In 1925, a committee on a coöperative program of corn improvement in the Corn Belt was appointed by the American Society of Agronomy. The committee, representing Illinois, Indiana, Iowa, Kansas, Minnesota, Missouri, Nebraska, and North Dakota, held two meetings, submitted a report outlining problems requiring research, and arranged for a comprehensive symposium at the meeting of the Society held in November of that year. This program, involving such other States as Michigan, Ohio, South Dakota, and Wisconsin, was operated through informal coöperation and coördination by the continuing committee.

Southern States.—Considerable work was done in the Southern States prior to 1920, by the former Office of Corn Investigations,

but none in coöperation. Later experiments were carried on co-operatively in Louisiana and Tennessee.

Louisiana Station: A Federal agent was placed at the Louisiana Experiment Station in 1922 to have direct charge of coöperative investigations. Reports of progress in production methods and improvement have appeared in the biennial reports of the station, and the results of testing and developing varieties were published (46—210) in 1930. Other coöperative studies appear under Protection.

Tennessee Station: A Federal representative was put at the Tennessee Station also. The results of studies on the productiveness of selfed lines and their hybrids in 1922 and 1923 were published (90—1354) in 1925, under joint authorship and with cover statement of coöperation.

Northeastern States.—Connecticut Stations: The State station at New Haven and the Storrs (Agricultural College) Station at Storrs, then independent in administration, in 1924 published results of studies planned and conducted coöperatively by the two stations (20—259) on corn in Connecticut. In 1920, the Federal Division of Cereal Crops and Diseases began coöperation with the Storrs Station on the effects of early planting on composition and yield and published results (21—151) in 1928.

New York (Cornell) Station: In about 1924 a cytologist was placed at the Cornell Station by the Federal agency to conduct coöperative research in the cytology of genetics of maize. A publication on chromosome numbers (70—117) appeared in 1928 and one on cytogenetics of tetraploid maize (41—50:591) in 1935. In the meantime, in 1932, a study of the inheritance of colored scutellums (92—292) was published by another coöperator at the Cornell Station.

Corn Belt States.—Illinois and Indiana Stations: The Federal-State research conducted in these two States was primarily in maize diseases. These studies led to a breeding program which included improvement activities in other than protection from diseases. The whole program was begun on the extensive farms of Funk Brothers Seed Company, noted breeders at Bloomington, in 1918, and made coöperative with the State station later, in about 1922. A program of corn improvement was formulated (36—284)

in 1924. Research on the extent and anchorage of root systems was published (41—27:71) in the same year. The State also published a comprehensive discussion of conditions influencing lodging in corn (35—266) in 1925, under joint authorship. Research on the chemical transformation of phosphorus in maize plants and its effect on first-generation crosses was published (41—46:121) in 1933. In 1934, a State-wide test of the comparative performance of 177 strains from many sources was conducted in Federal-State coöperation, the State Natural History Survey assisted, and the publication of results was under three-way authorship (35—411). In Indiana, the work was mostly on protection from diseases, but sweet-corn breeding was followed and a new Golden Bantam hybrid developed (93—268) in the ten years ending in 1932.

Iowa Station: In 1922, the Federal-State coöperative investigation of cereals at the Iowa Station was expanded to include maize. In 1920, the Station, jointly with the Iowa Corn and Small Grain Growers' Association, had begun a State-wide coöordinated test of varieties, strains, and hybrids in order to determine adaptation to the twelve districts into which the State was divided. From 1922 onward the Federal Division coöperated also. Reports of results are published annually (39—343) to 1935, and a comprehensive summary of eight-year results was issued (39—265) in 1929. The test continues. Inheritance studies and breeding have made up most of the program and a very large number of coöperative publications has resulted, of which only a few can be cited (40—138; 41—39:677 and 44:495). In a study of the response of sweet corn to varying temperatures from seeding to canning maturity, conducted from 1922 to 1927 by the Federal Division of Horticultural Crops and Diseases, two-year results were furnished by the Iowa Station (92—312). Data on the factors of experimental error in field-plot tests were published (40—163) in 1933.

Kansas Station: Beginning in 1923, the Federal Division of Cereal Crops and Diseases placed a coöperating maize breeder at the Kansas Station. Results of the first two years of investigation are included in a report on corn production in Kansas (42—238). A wide range of studies of physiologic and genetic problems was begun. Among many coöperative publications are one on conditions affecting popping quality of popcorn (41—35:615) and one on the

effect of failure of pollination on the composition of plants (41—49:45).

Minnesota Station: As part of the Corn Belt interstate corn-breeding project, organized in 1925 by the committee mentioned in the introduction to this subsection, Minnesota began coöperative breeding studies and in 1930 published on double crosses (55—275).

Missouri Station: The Missouri Station Departments of Botany and Field Crops coöperated in studies of inheritance in maize kernels (59—52) and also in root-rot studies (59—113), made public in 1922 and 1927 respectively. In about 1926, the Federal Division of Cereal Crops and Diseases began genetic research on maize in coöperation with the Station. The major problem was the effect of irradiation on genetic results. Publication of coöperative results began in 1931. Studies on the genetic nature of induced mutation were published (59—204) in 1933. Some assistance in this special field was received from the Division of Biology and Agriculture of the National Research Council (see p. 487).

Ohio Station: In connection with the Federal-State campaign for cornborer control, discussed later under Protection, coöperative research in the physiology of maize was started. Some of the results, such as methods of determining bound water in plant tissue (41—44:669) and differential response of varieties to fertility levels and to seasons (41—49:991) are related to production.

Great Plains Area.—Maize was included in the rotation and tillage experiments conducted by the Federal Division of Dry-Land Agriculture, independently and in coöperation with States from 1905 onward, the results of which were presented under General Production of Cereals. Some special compilations of results from corn were published by the Federal agency (90—219 and 242) in 1915.

Bulletins devoted wholly to corn also were published by the Montana Station for the Judith Basin Substation (60—132) and the Huntley Substation, both on dry land (60—140) and under irrigation (60—193), the latter including coöperation by the Federal Division of Western Irrigation Agriculture also. A further dry-land publication in 1926 contained data from three dry-land coöperating stations (60—194).

In North Dakota, both Divisions, Cereal Crops and Diseases and Dry-Land Agriculture, coöperated in maize-production studies and results were presented by the State (74—207 and 257) in 1927 and 1932.

Protection from Disease and Climatic Factors

The principal maladies of the maize plant are fungus and bacterial diseases, insects, and climatic factors. The chief fungus diseases are smut, the root-, stalk-, and ear-rots, and bacterial wilt. The principal insect enemy is the corn borer, with chinch bugs second, and the most injurious climatic factor is frost.

Smut and rust of maize. Maize smut: The smut of maize is a common and destructive disease spread by spores carried in the air. Seed treatments, therefore, are not effective. Pathologists of the Federal Division of Cereal Crops and Diseases have conducted research in this disease coöperatively with the States since 1922. Preliminary studies of the relation of temperature to smut-spore germination were presented (41—24:593) in coöperation with the Wisconsin Experiment Station. Collaborative research was begun at the Kansas Station as early as 1916, and studies of life history and ecologic relations of the fungus (41—30:161) and resistance of corn seedlings in the greenhouse (41—32:649) were published under joint authorship in 1925 and 1926. Physiologic research on the fungus and the host were continued independently by the Federal agency, with assistance from several States in supplying material. Breeding for resistance is in progress at coöperating stations under the regional program of maize improvement. Independent Federal study of the relation of husk covering to smut infection has been made (92—120). The coöperative research on the head smut of sorghum, which affects maize also, is presented in the next subsection, on Grain Sorghum.

Maize rust: The rust of maize (*Puccinia sorghi*), though not usually destructive, has been studied in the Federal-State leaf-rust research at the Indiana Station, beginning in 1918. Studies of the inheritance of resistance to physiologic forms of the rust were presented (41—43:419) in 1931. As of the other cereal rusts, the cytologic research on heterothallism was done in coöperation with the California Station and published (41—49:1047) in 1934,

with acknowledgment of material from collaborative experiments at the Illinois, Indiana, and Kansas Stations.

Root-, Stalk-, and Ear-Rots.—Several different fungus organisms, belonging to different genera, such as *Diplodia*, *Fusarium*, *Gibberella*, *Cephalosporium*, *Helminthosporium*, *Penicillium*, *Pythium* (and others) cause rots and molds of maize. Some of these represent the imperfect and perfect stages of the same fungus. One of the most important is the *Fusarium* rot, of which the perfect stage is *Gibberella saubinetii*. Coöperative Federal-State research on this complex and difficult group of diseases has been conducted at the Indiana, Illinois, Iowa, and Wisconsin Stations. Much of the research in Illinois was coöperative also with Wisconsin.

Indiana Station: Coöperation of the Federal Division of Cereal Crops and Diseases with the Department of Botany of the Indiana Station began in 1918. One of the first results of the studies there and of similar coöperation in Wisconsin was the discovery of the relation of one maize root rot and the head scab of wheat (41—14:611), previously noted under Protection of Wheat, and published under three-way authorship. From 1918 to 1922, the Indiana Station issued coöperative bulletins on selection of disease-free seed of field maize (37—224) and of sweet corn (37—233), and a study of the modified rag-doll germinator and the germinator box (37—236). In 1922 the Federal agency published on the relation of endosperm characters to susceptibility to root rotting (90—1062). Early in the Indiana investigation it was noted that the nodal tissues of many plants showed discolorations, found to be caused by accumulations of iron and aluminum. The relation of these phenomena to the root-rot diseases (41—23:801) and to soil-nutrient deficiencies was investigated (37—298) and published in 1923 and 1926.

Illinois Station: In Illinois the study of corn breeding and of corn diseases was begun in 1918 in coöperation with Funk Brothers' Seed Company at Bloomington. At the same time the Wisconsin Station was intimately associated with the project, as will be noted below, especially in the laboratory research. Control of these rot diseases by seed selection was sought from the beginning (36—243). The influence of these diseases on early vigor and yield of maize appeared, jointly authored (41—23:583), in 1923, while

the State published a most comprehensive discussion (250 pp.) of these diseases and their control through seed selection and breeding (35—255) under Federal-State authorship in 1924. Factors influencing lodging of maize were presented (35—266) in 1925, chemical dusts for seed treatments (93—34) in 1928, and results of seed treatments (92—260) and control of corn diseases in Illinois (36—364) in 1931, all under joint authorship. A second comprehensive summary of the nature, extent, and control of these diseases in Illinois appeared (35—354) in 1930.

Wisconsin Station: The greenhouse and laboratory research in *Gibberella saubinetii* at the Wisconsin Station was correlated and sometimes actually in coöperation with that carried on in Illinois. A comprehensive study—in the years 1919–21—of the influence of soil temperature and moisture on the development of the seedling blight of wheat and maize was published (41—23:837) in 1923. The identity of another *Fusarium* and its perfect stage, another *Gibberella*, appeared (41—28:909) in 1924, as did also, under three-way authorship, a study of the relation of the root rot to crop rotations (41—27:861). A critical research into the parasitism of the organism was presented (41—43:569) in 1931.

A comprehensive study of another organism, *Cephalosporium*, causing the black-bundle disease of maize, was issued (41—27:177) in 1924. A study of still another seedling blight and root rot, caused by a species of *Pythium*, published (41—37:443) in 1928, was made with the assistance of Funk Brothers' Seed Company and the Illinois Wesleyan University. A later comprehensive study of a seedling blight caused by a *Penicillium* (41—43:757), was published in 1931. Both of these papers were under joint authorship.

Iowa Station: A study of seed treatments against the various diseases of sweet corn, made in Federal-State coöperation with the Iowa and Illinois Stations, was issued under three-way authorship (41—33:769) in 1926.

Nebraska Station: Experiments conducted in Federal-State coöperation on seed treatments for maize, at the North Platte Substation, in 1929, were published (65—38) in 1930.

Other maize diseases.—Besides the various rots and blights, maize is affected by a downy mildew, a *Physoderma* disease, a bacterial wilt, and a mosaic disease of unknown cause.

Downy mildew: In 1918, a Federal pathologist was sent to the Philippine Islands to investigate a downy-mildew disease known to be very destructive to maize under Philippine conditions. Because of the possibility of its introduction to this country, a full knowledge of its character and control was highly desirable. Facilities for the research, and other forms of coöperative assistance, were furnished by the College of Agriculture of the University of the Philippines, and the Philippine Bureau of Agriculture and Bureau of Science. The study, made under great natural handicaps, was completely successful, so that papers describing new species of the organism appeared (41—19:97, 20:669) in 1919 and 1920 and later, in 1923, papers discussing production and dispersal of spores (41—23:239) and seed treatments (41—23:853). Not the least of the difficulties encountered was the completely nocturnal production of the conidia (41—19:97 and 27:771). A final paper, covering the effects of the disease observed in teosinte, a wild relative of maize, appeared (41—39:817) in 1929.

Physoderma disease: From 1916 to 1918, the Federal Division of Cereal Crops and Diseases surveyed the distribution and studied the habits and possibility of control of the widely distributed *Physoderma* disease of maize (41—16:137). The study was independent of any State station, but information and assistance were received from many officials.

Bacterial wilt: The bacterial wilt, or Stewart's disease, of maize has long been the subject of research, though usually noncoöperative. In 1926, a Federal-State coöperation with the Iowa and Illinois Stations on seed treatments for sweet-corn diseases (41—33:769) included data on this wilt. In 1928, studies of the resistance of dent corn to the disease, conducted in coöperation with Funk Brothers' Seed Company in Illinois, were presented (41—36:905). A study of the life history of the organism, in coöperation with the Wisconsin Station, appeared (41—47:749) in 1933. In the same year the Federal Division of Horticultural Crops and Diseases summarized a long-time study (92—362) conducted by the former Division of Plant Pathology in coöperation with the West Virginia Station, with assistance from the Maine Station.

Mosaic disease: Under the Federal-State corn-breeding program at the Louisiana Station, data were obtained on the influence of

the mosaic disease of maize and sugar cane on the productivity of maize (92—10), with publication in 1927.

Frost injury.—Frosts in the late spring and in early autumn do great damage to the maize crop in certain seasons. Selection and breeding for frost resistance constitute the only practicable remedy. Much investigation in this field has been conducted by the Federal Division of Cereal Crops and Diseases in coöperation with Funk Brothers' Seed Company and the Illinois Station. Special apparatus for determining cold resistance of growing plants in the field was devised and described (93—285), after several years of use and improvement.

European corn borer.—The discovery of an infestation of the European corn borer in Massachusetts in 1917 and in southern Ontario, Canada, in 1920 revealed a most serious threat to the American corn crop and brought about a complete and widespread coöperation in the attack on the problem. That the coöperation was informal rather than under formal signed agreements in no way lessens its value or makes it less remarkable. Its institutional scope covered the United States and Canadian Departments of Agriculture, State and Provincial departments of agriculture, State and Provincial colleges of agriculture with their experiment stations and extension divisions, legal departments and courts of many jurisdictions, State and local boards of health, and some foreign governments and institutions. Its technical scope included entomologists, agronomists, geneticists, agrostologists, botanists, ecologists, chemists, animal and dairy husbandmen, extension specialists, agricultural economists, agricultural writers, agricultural engineers, attorneys, administrators, budget officers, and legislators. In the commercial world the interest and concern was equally widely distributed, and the manufacturers of agricultural machinery, processors of agricultural crops, and similar groups took an active part in the movement.

For the first few years, surveys of distribution and research in life history and control methods were the chief activity. By 1924 it had become evident that the spread toward the real corn belt was steady and alarming, and group action for control was begun on a coöperative basis (5).

International Corn Borer Organization: In the autumn of 1925,

a conference was called at Toledo, Ohio, by the directors of the State experiment stations in the northeastern and north central States. At this meeting, which included Canada, the International Corn Borer Organization was formed. It acted as a general clearing-house for information and action, sponsored three-day field-inspection trips and conferences in September of each year thereafter, and issued comprehensive mimeographed reports for 1926 to 1928, inclusive. At the meeting in 1926, a Public Relations Committee was appointed to develop State and Federal legislation, appropriations, and a program for a gigantic cleanup campaign in 1927. After several meetings of this committee, conferences were held in Washington, with the Secretary of Agriculture, Director of Research in the Department, Director of the Budget, Committees on Agriculture in the House and Senate, and the President of the United States. The result was Federal and State legislation, a Federal appropriation of \$10,000,000, and a rapidly organized cleanup campaign on the western border of the infection. Of the amount appropriated, some \$4,200,000 were paid to farmers for the extra labor involved, while \$3,000,000 were paid out for machinery and supplies.

Joint Committee on Corn Borer Problems: At the (first) annual meeting of the International Corn Borer Organization in Toledo, Ohio, in 1925, it was voted that the American Association of Economic Entomologists and the American Society of Agronomy be asked to appoint committees on the corn-borer problem and that these form a joint committee. Five men being named on each committee, a joint committee was formed and in 1926 presented recommendations. In that year it was voted to request similar committees from the American Society of Agricultural Engineers and the American Farm Economic Association. The Engineers appointed their committee for service in 1927 and the Economists created theirs in 1928. In that year the American Society of Animal Production was asked to take similar action and thereafter the Joint Committee was made up of five representatives from each of these five organizations. In January, 1927, a conference of Canadian and United States workers on corn-borer problems was called in Washington to prepare for the research and cleanup programs of the ensuing season. This midwinter conference was held annually there-

after until 1934. The Joint Committee reported to the International Corn Borer Organization at the field conference in September each year, then back to its component societies for approval of recommendations at their winter meetings, and finally to the annual mid-winter Washington conference. Their mimeographed reports were included with those of both conferences and also were distributed separately.

In addition to the enormous volume of informal coöperation involved in these conferences and committee programs, there was much definite or formal coöperation in certain lines. This coöperation was international, interinstitutional, interbureau, and interdivisional. The more important fields and agencies are indicated below. The principles underlying coöperation in corn-borer research were discussed (5) in 1927. A bibliography of the borer was issued (95—46) in 1925 and revised in 1928.

Investigation in Europe and the Orient: In 1919, a laboratory for the investigation of the life history and especially the parasites of the borer was established in France. Later the field studies were extended to several other countries of Europe. Much assistance was received from officials and institutions of the various governments. A study of controlling factors (92—59) was issued in 1928 and a summary of the investigations in Central Europe from 1924 to 1927 was published (92—135) in 1929, with acknowledgments to foreign officials and also to foreign representatives of our Departments of Agriculture and State. From 1928 to 1932, the Federal Bureau of Entomology conducted studies of parasites of the borer in China and Japan and published the results (93—289; 92—455) in 1933 and 1934, with acknowledgment of assistance received from various officials and institutions. In America, the Canadian and United States Departments of Agriculture coöperated fully in biological control measures.

Surveys and quarantines: Surveys (scouting) to determine the presence and intensity of infection were carried on by the Bureau of Entomology and the Federal Horticultural Board from 1917 onward. Although virtually every State was engaged in surveys also, there seems to have been no coöperation in the work. In a comprehensive publication on the progress of all corn-borer work from 1917 to 1926, no mention is made of coöperation with any State

agency in surveys or quarantines (92—53). In public addresses it was said that the quarantines all were administered in coöperation with the States. In reference to quarantines at Michigan ports it was stated (*op. cit.*, p. 31) that the work was done in coöperation with customs officers of the Treasury Department.

Life history and control measures: After the rapid spread of the borer in 1925, several circulars (95—70, 84, and 104) were issued by the Federal Bureau of Entomology in coöperation with the Federal Horticultural Board and the various State departments of agriculture. A comprehensive progress report of investigations published (90—1476) in 1927, records coöperation with the Massachusetts Station in surveys in 1918 but independent surveys thereafter. No mention is made of coöperation in the extensive research activities. The comprehensive publication (92—53) on scouting, quarantine, and control from 1917 to 1926, makes in the prefatory discussion no mention of coöperation. In the text, however, minor coöperation is acknowledged at several points. With the Ohio Station, studies were made in 1925 of the use of husker-shredders (*op. cit.*, p. 53) and silage cutters (p. 55), in plowing tests (pp. 60, 68) in 1925 and 1926, and in varietal and date-of-seeding comparisons with field and sweet corn (p. 95) from 1923 to 1925. The latter tests were transferred to the Michigan Station in 1926, for one season (*op. cit.*, p. 97), as noted also by the Michigan Station (53—204) in 1930. So also were the husker-shredder tests (p. 54). Date-of-seeding comparison of both field and sweet corn was conducted in coöperation with the Massachusetts Station at its Market Garden Field Station at Waltham from 1923 onward (*op. cit.*, p. 100). An extensive study of host plants of the borer in New England, conducted chiefly from 1919 to 1922, also contains no mention of any coöperation (92—77). Two New Hampshire bulletins (67—30 and 33), on submergence of larvae and the life history of the borer, issued in 1926 and 1927, were both in coöperation with the Federal Bureau of Entomology.

In 1928, the Ohio Station Divisions of Entomology and Agronomy issued jointly a comprehensive discussion (76—429) of the borer and its environment. Other agencies coöperating in parts of the work were the State Department of Agriculture, the Departments of Entomology and Agricultural Engineering of Ohio State

University, and the Federal Bureau of Entomology, in tests of low-cutting corn binders in 1924 and 1926; the Department of Botany of Ohio State University in the vegetation survey since 1926, with assistance from the Entomological Branch of the Canadian Dominion Department of Agriculture; the Federal Bureaus of Plant Industry and Entomology and the Department of Farm Crops of Ohio State University in agronomic studies since 1927; and the Federal Bureau of Chemistry and Soils in the correlation of soil types with borer abundance since 1927. In 1926, the Wisconsin Station published a warning bulletin on the corn borer (146—385), which was unique not only in being the joint composition of the Station and the State Department of Agriculture but also in being issued as that Department's *Bulletin* (No. 75).

Farm management: The importance of reorganizing farm-management practices in the face of borer invasion brought the agricultural economists into the Joint Committee on Corn-Borer Problems, as noted previously. In 1928, the Federal Division of Farm Management, in coöperation with the corresponding unit in Ohio State University, authored jointly a discussion of farm practices under corn-borer conditions (91—1562), based on coöperative studies in 1927 which included the Michigan Station and Extension Division also. In 1930, these studies were conducted coöperatively in Indiana and Michigan and type-of-farming studies were conducted in several States. In 1929, studies of farm-management practices in the use of corn stover were conducted coöperatively in Illinois, Indiana, Michigan, and Ohio.

Control by machinery: Through the activities of the representatives of the American Society of Agricultural Engineers on the Joint Committee, there was far-reaching coöperation between the Federal Division of Agricultural Engineering and the corresponding Department of Ohio State University from the beginning, with less intensive coöperation by the engineers in Michigan and other States. This has been fully presented in the chapter on Agricultural Engineering and need not be repeated here.

Other coöperative activities: In recent years, Federal-State coöperation in breeding maize with reference to corn-borer conditions has been conducted in Iowa, Kansas, Missouri, Nebraska, and Ohio. Soy beans as a partial substitute for corn have been tested



in coöperation with the Ohio Station and University. Federal and State animal-husbandry units have coöperated in several States in the use of stalks for feeding in different ways. Insecticide investigations have been conducted in coöperation with the Connecticut (New Haven) Station, and the Bureau of Chemistry has aided by synthesizing insecticides.

Other insect pests.—*Chinch bug*: The Illinois Station and the State Natural History Survey coöperated in studies of chinch-bug control through chemical treatments and resistant varieties (35—243 and 249), published in 1923 and 1924. In the Station the Divisions of Entomology and Farm Crops were concerned, and some corn varieties were contributed by the Federal Division of Cereal Crops and Diseases.

Stalk borer and ear worm: In Virginia, a four-year study of the larger stalk borer, begun in 1916, was coöperative between the Virginia Station (140—22), the State Crop Pest Commission, and the Federal Bureau of Entomology. An extensive study of the corn ear worm, conducted from 1921 to 1928 by the Virginia Station and the Federal Bureau of Entomology, covered hibernation, husk protection, and egg-laying habits (140—40, 43, and 47), respectively.

GRAIN SORGHUMS

Sorghums usually are classified into four groups: grass sorghums, sorgos or saccharine sorghums, grain sorghums, and broomcorn. The first and second groups belong to forage crops and the second to sugar crops also. The third, although called grain sorghum, serves for forage also. The fourth group belongs to fiber crops.

The development of the grain-producing sorghums was from crops (kafir, milo, feterita, durra), and varieties of them, which were originally grown for forage, and substantially all of them still have the two uses. The Federal census classifies them as grain crops when they are threshed for grain. If fed in the head or bundle they are classed as forage crops, just as the oat crop is in similar circumstances.

Production and Improvement

The activities in production and improvement include introductions from foreign lands, testing for adaptation to various condi-

tions, studies of cropping methods, selection and breeding, and the development of machine harvesting. As they are relatively new crops in America, and absolutely new to many farmers using them, these production problems have been more pressing than for older and better-known crops. These conditions resulted in some general discussions of these crops, including history and distribution (121—175), importance and improvement (121—203), the kaoliangs (121—253) and immigrant crops which have made good (99—1913:221), all published between 1910 and 1913 and representing minor coöperation by several States in making preliminary experiments on adaptation. The sorghums, and especially the grain sorghums, are adapted to dry-land conditions and therefore their area of greatest culture is in the southern and central sections of the Great Plains Area.

Federal interunit coöperation.—In the Federal Bureau of Plant Industry, several divisions have coöperated extensively with the Division of Cereal Crops and Diseases in studies affecting grain sorghums, especially Foreign Plant Introduction, Forage Crops and Diseases, and Dry-Land Agriculture, with limited aid from Western Irrigation Agriculture. Foreign Plant Introduction has aided greatly in obtaining new material desired from Africa (121—122), India, and China and Manchuria (121—253), the three great sorghum-producing regions of the Old World (121—175).

It is natural that the Federal Cereal Crops and Forage Crops Divisions should work together on these crops, which, as noted at the beginning, are both forage and grain producers. In fact, the first Federal expert on this group of crops started on forage sorghums in 1900 and progressed gradually to work on grain sorghums by 1907. A comprehensive summary of sorghum experiments in the Great Plains, prepared by Forage Crops in coöperation with Cereal Crops, contains data on both forage and grain varieties (90—1260), obtained from Federal and State stations in the four southern-plains States with the coöperation of the Division of Dry-Land Agriculture and the Kansas and Texas Experiment Stations.

The Division of Dry-Land Agriculture established a series of independent or State-coöperative dry-land field stations throughout the Great Plains in the first decade of this century, as described under General Cereal Production. Grain and grain-forage sor-

ghums were included in the extensive rotation and tillage experiments, as well as in the limited varietal comparisons on these stations. The latter soon were made informally coöperative with the Division of Cereal Crops. The results have appeared in the publications listed under General Cereal Production and also in other bulletins, such as those on sorghum experiments at Woodward, Oklahoma (90—1175), sorghum experiments in the Great Plains (90—1260), and spacing and date-of-seeding experiments (92—131), all of which include data from stations of that Division.

In 1926, a Federal-State investigation was made of hand and machine methods of harvesting grain sorghums, with special reference to the use of the combined harvester-thresher or combine. The three Federal units were the Divisions of Farm Management, Bureau of Agricultural Economics; Cereal Crops and Diseases, Bureau of Plant Industry; and Agricultural Engineering, Bureau of Public Roads. The State agencies were the three comparable units from the Kansas and Oklahoma Stations, and the Engineering Experiment Station of the Kansas State College. The combined data were published (92—121) by the Federal agencies, under joint authorship, in 1929. The Oklahoma data were published by the State (77—162) in 1927.

Federal-State coöperation.—There has been formal or informal coöperation by the Division of Cereal Crops and Diseases with several State stations in investigations of grain sorghums. The principal coöperation has been with the Kansas Station.

Arizona Station: Cereal-crops coöperation was begun at the Arizona Station in about 1931 and a study of the effect of tillers on the development of grain sorghums was published under joint authorship in 1935.

California Station: When the general cereal experiments were made coöperative with the California Station in 1922, only the small grains were included. Much work has been done by the Station in the breeding and selection of sorghums, but coöperation with the Federal agency has been merely nominal, confined largely to the exchange of varieties and suggestions.

Colorado Station: Part of the Federal Field Station of the Division of Dry Land Agriculture at Akron is owned by the State, and the cereal experiments have been considered coöperative. Grain

sorghums are of minor importance so far north but have been thoroughly tested and results reported (90—402 and 1287) in 1916 and 1925, for the period 1908 to 1922 inclusive.

Kansas Station: Informal coöperation on grain-sorghum experiments was begun at the Fort Hays Branch Station in 1908 and formal coöperation in 1910. A compilation of data on experiments from 1912 to 1923 was published by the Federal agency (92—14) in 1927. A comprehensive study of spacing and date-of-seeding, coöperative with this station but including data from other stations, was issued (92—131) in 1929. Recently the State has published two comprehensive jointly written bulletins containing coöperative results, one covering sorghum production (42—265) and the other on sorghum varieties (42—266), issued in 1933 and 1934. Genetic studies made at both the Branch Station and the State Station have appeared from time to time (41—37 :577 and 49 :663). The rotation and tillage studies in coöperation with the Division of Dry Land Agriculture have been noted under General Cereal Production. One special study appeared elsewhere (41—32). The respiration of sorghum grains was studied by the Grain Division, Bureau of Agricultural Economics, and the Kansas and Oklahoma Stations as part of a general program on conditions influencing grain storage (92—100).

Nebraska Station: Grain-sorghum experiments were conducted coöperatively at the North Platte Substation in Nebraska and the results for the period 1924—33 have just been issued (63—297) by the Station in 1936.

Oklahoma Station: Grain-sorghum experiments were begun on the Woodward Field Station of the Division of Dry Land Agriculture in 1914 and the results of interdivisional coöperation published (90—1175 and 1260; 92—131) at intervals. Inheritance of seed color was studied also and published (41—27 :53 and 47 :663). The work was made coöperative with the Oklahoma Station in about 1930, and later results were published (77—210) under joint authorship in 1933. In December, 1935, a formal agreement of coöperation was effected by the Federal Bureaus of Entomology and Plant Quarantine and Plant Industry and the Oklahoma Station, providing for research on breeding for chinch-bug resistance of cereals, including grain sorghums, at the Lawton Field Station.

South Dakota Station: Experiments with cereals, including grain sorghums, were begun at the Highmore Substation in South Dakota, in coöperation with the State, in about 1908, with results published by the State (86—135 and 156) in 1912 and 1914. Experiments conducted on the Belle Fourche Field Station at Newell, nominally in coöperation with the State, were reported (90—297 and 1039) in 1915 and 1922. In general, these crops are not adapted to that northern area.

Texas Station: Grain-sorghum experiments were conducted from 1904 to 1920 in the Panhandle of Texas (121—283; 90—698 and 976) with the friendly interest of the State station. Experiments were begun at about the same time at the Chillicothe Substation, in coöperation with the Division of Forage Crops and the State Station. These results were included in the general compilation of results in the Great Plains (90—1260) in 1924. Recently the State has published these and other results on spacing and date-of-seeding experiments (88—424) and varietal comparisons (88—459), in 1931 and 1932, under Federal (Forage Crop)-State authorship.

Protection from Pests

The principal diseases affecting the sorghums are the two kernel smuts, covered and loose. There likewise is a head smut, which affects maize also. Other maladies are a leaf rust, bacterial blights, and sterility caused by an insect, the sorghum midge.

Kernel and head smuts.—The two kernel smuts are similar and have been confused. Extensive Federal-State investigation of the three smuts, and of varietal resistance of sorghums to them, was made by the Federal Division of Cereal Crops and Diseases, the Kansas Experiment Station, and the Brooklyn Botanic Garden (90—1284) and published in 1925. Thereafter, critical research was conducted by the Federal and State agencies into physiologic specialization and heterothallism in the two kernel smuts (41—34:825, 44:1, 45:287, and 49:1069) and published between 1927 and 1934. From 1919 to 1925, also, the coöperation at the Kansas Station included chemical control of the kernel smuts and the effect of seed treatments on seed vitality and vigor of growth (43—22).

Head smut, affecting both sorghum and maize, was studied by the Federal Division over a period of years beginning in 1907 and

the results, obtained through minor coöperation by several States which grew the material, were published (41—2:339) in 1914. Co-operative studies were made later at the Washington Station also (143—119) and issued in 1920. The later extensive investigation of this smut in coöperation with the Kansas Station and the Brooklyn Botanic Garden, published in 1925, already has been mentioned (90—1284) in connection with the kernel smuts.

Other diseases.—Leaf rust of sorghum was investigated in the general research on leaf rusts of cereals, coöperative between the Federal Division of Cereal Crops and Diseases and the Indiana and Kansas Stations.

Extensive research in a bacterial stripe disease was conducted by the Federal agency with Federal interdivisional coöperation and minor coöperation from the Kansas Station (41—38:1), with results published in 1929.

A sterile condition of sorghum heads, known as blast, long thought to be caused by climatic conditions, was made the subject of study by the Federal Division, in coöperation with the Louisiana Station and the Plant Industry Division of Western Irrigation Agriculture at its station at San Antonio, Texas, in 1907. A small insect, the sorghum midge, was discovered to be the cause (6). The study was continued in 1908 by the Federal Bureau of Entomology in coöperation with the Louisiana Station and the results were published (109—85) in 1911. Investigations of practices designed to bring grain sorghums to flowering in periods when midges normally are not abundant were continued at San Antonio, Texas, the results being published (121—237) in 1912 and again (90—188) in 1915.

MILLETS

Certain millets, including the Russian proso or panicle millet and the foxtail millets, were tested extensively in the dry-land areas of the Great Plains and Great Basin during the early years of this century. The chief interest lay in their short growing season and presumably low water requirements.

Varieties of foxtail millet (*Setaria*), such as Hungarian, Common, and Korean, were studied, as well as numerous varieties of proso (*Panicum miliaceum*). The results, usually, were presented in the cereal publication noted under General Cereal Production,

the outcome of independent Federal and Federal-State activities in those areas. A few State publications have been issued, as in Colorado (19—383) on proso and in South Dakota (86—135) on millets and sorghums.

Almost no coöperation on millet protection has been recorded, because these crops have few diseases. Research in a downy mildew affecting a wild relative of the foxtail millet, in Florida, was conducted coöperatively by the Federal Division of Cereal Crops and Diseases and the Florida Station (41—36 :935) and published in 1928.

The publications listed in the Literature Cited at the end of this chapter which have been cited in these subsections on Maize, Grain Sorghums, and Millets are Nos. 2, 5, 6, 12, 19, 20, 21, 35, 36, 37, 39, 40, 41, 42, 43, 46, 53, 55, 59, 60, 63, 65, 67, 70, 74, 76, 77, 86, 88, 90, 91, 92, 93, 94, 95, 99, 109, 121, 140, 143, and 146.

4. FORAGE CROPS

FORAGE CROPS include all pasture, hay, and fodder plants used by livestock. Pastures include all grazing areas, such as the western range, all natural pastures of other areas and the seeded pastures of more intensive farming. Hay crops include wild-grass hays and all cultivated grasses and legumes used for hay, including grain hays. Fodder crops include such coarse grasses as maize, the sorghums, and certain large millets, as well as root crops. Most of these fodder crops and some legumes also are used for silage. Besides all of these, many shrubby browse plants must be included, as they make up a considerable part of the forage of grazing animals in wooded areas, especially in the West.

Discussion of forage crops is complicated by the fact that many of them have other uses. The small grains, for instance, may be pasture and hay crops also. Maize and the grain sorghums are used likewise for fodder and silage. Many grasses furnish both pasture and hay. Soybeans and peanuts are oil crops as well as forage.

OFFICIAL AGENCIES

Many different Federal and State agencies are concerned in the production and protection of forage plants. The principal ones are the U. S. Department of Agriculture, the State colleges of agri-

culture with their agricultural experiment stations and extension divisions, and the State departments of agriculture, usually concerned chiefly with regulatory activities.

Federal Agencies

In the U. S. Department of Agriculture several successive units have been charged with the investigation of forage crops. From 1865 to 1895 the Division of Botany gave attention to grazing plants on the range, especially grasses. In 1895, an independent Division of Agrostology was created and in 1901 it became an Office of the newly created Bureau of Plant Industry. Shortly thereafter it was renamed the Office of Forage Crop Investigations. In the meantime an Office of Vegetable and Forage Crop Diseases had been established. In 1928, this latter office was abolished and the Office of Forage Crop Investigations became the Office and later the Division of Forage Crops and Diseases. In the Bureau of Entomology a Division of Cereal and Forage Insects was established long ago for the investigation of insect pests of these crops.

The influence of individual leaders on organization units is well illustrated by what happened in the field of forage crops. In 1902, just as the Office of Agrostology was becoming the Office of Forage Crop Investigations, a new chief was appointed who was largely interested in farm-management affairs. For several years he conducted both lines of investigation and many of the early forage-crop studies under his direction were made from the standpoint of farm management, for which a separate office was established. In 1906 the two offices, Forage Crops and Farm Management, were put under separate leaders, but for some time thereafter most of the studies, including pastures and haymaking, were conducted in more or less close coöperation (121—94). Some forage-crop activities remained wholly in the Office of Farm Management. These included range investigations and studies of cactuses and some other dry-land plants, as well as the eradication of farm weeds.

Other Federal agencies taking part in the forage-crop investigations are the Forest Service, which is charged with grazing operations in the National Forests; the Bureau of Chemistry and Soils; the Bureau of Agricultural Economics, through its Division of Farm Management; the Bureau of Agricultural Engineering, with

respect to the use of farm machinery—especially the use of the combined harvester-thresher, or combine, in harvesting sorghums and soybeans.

The Plant Industry Offices of Dry Land Agriculture and Western Irrigation Agriculture have conducted many experiments with forage crops on the independent and cooperating field stations under their control in the Great Plains and farther west.

State and County Agencies

In the State colleges of agriculture, the agricultural experiment stations and the extension divisions are the units concerned. In the stations, the division of agronomy or farm crops has charge of most forage investigations. Assistance is rendered or cooperation given by such other divisions as animal husbandry, dairy husbandry, chemistry, entomology, plant pathology, agricultural economics, and agricultural engineering.

The State departments of agriculture, in general, are concerned with quarantine measures for the control of fungus diseases and of insect pests such as the alfalfa weevil. In North Carolina, however, the State Department of Agriculture shares with the State College the responsibility for the maintenance of the Agricultural Experiment Station. In Illinois, the State Natural History Survey has separate funds and personnel which sometimes are applied to investigations. In Colorado, the State Entomologist has similar funds and activities.

County officials usually take little part in forage-crop investigations. In a few counties, however, they aid in control measures directed against pests, and then chiefly as representatives of the State department of agriculture. A few instances are noted in the discussion which follows.

GENERAL FORAGE INVESTIGATIONS

Federal activities in forage crops cooperative with State stations developed slowly but steadily during the first fifteen years of the present century. During that period, as noted above, both the Office of Forage Crop Investigations and the Office of Farm Management were working in this field. During the second fifteen years, from 1916 to 1930, forage-crop studies developed more rapidly. By

1930 there was some definite coöperative project in each of twenty-five States, including those in which the testing of the adaptation of red clover from different sources was conducted. More recently, these minor and temporary projects have been completed. Emphasis is now focused on fewer locations and a broader range of studies designed to meet the problems of a given State or group of States. In 1935 there was some Federal coöperation with the experiment stations of seventeen States. There also were minor coöperative activities with the Division of Dry Land Agriculture on numerous independent and coöperating stations in the Great Plains Area.

The general projects will be discussed by regions, after which the more important coöperative studies on major groups of both grass and legume forages will be presented. Owing to the limited coöperation in research on diseases and insects of forage crops, no separate subsection on protection is given but these protective activities are presented with each crop group or crop.

Southern States

Early forage-crop surveys were made in the Southern States by the Division of Agrostology, beginning in the southeastern States in 1895 and in Louisiana in 1898. They were continued by the Bureau of Plant Industry for several years after 1901. Much information and some other assistance was given the Federal investigators by the officials of the State stations, but there was no formal coöperation in this work.

Beginning in 1925, extensive tests of the adaptability of red-clover varieties from various foreign sources were carried on under Federal-State coöperation, including Kentucky, Mississippi, and Tennessee among the southern States. At the time of the great flood of 1927 in the Mississippi Valley, a circular (95—106) on emergency crops for flooded lands was issued by the Federal Extension Service and the Bureaus of Plant Industry and Entomology. Beginning in 1928 the Division of Forage Crops and Diseases and the Agricultural Economics Division of Farm Management and Costs jointly conducted and authored a study of the use of winter legumes in the southeastern States (91—1663; 92—367), acknowledging information received from the Alabama, Georgia, and South Carolina Stations and the Georgia College of Agriculture.

In coöperation with the Mississippi Station, experiments on forage plants were conducted at the State Alfalfa Experiment Station at West Point. While alfalfa was the primary problem, many forage crops were studied and results (92—419) to the end of 1931 were published. In coöperation with the Missouri Station, special tests of *Lespedeza sericea*, the new perennial lespedeza (58—331), were conducted from 1931 to 1933. In 1932, in the beginning of Federal-State coöperation at the Florida Station on general forage-crop problems, a study of a laboratory silo (41—47:617) was made in coöperation with the Station Departments of Animal Husbandry and Agronomy.

North-Central and Northeastern States

No early studies were made in these older-settled States because of the more pressing problems in the south and west. In later years, however, coöperative experiments were developed gradually. By 1931, the Federal Division of Forage Crops and Diseases recorded coöperation in Indiana on clover diseases; in Iowa on alfalfa, red clover, and soybeans; in Massachusetts on alfalfa and red-clover adaptation, and on soybean and sweet-clover production; in Ohio on the same crops except sweet clover; in Pennsylvania on pastures; in West Virginia on pasture fertilization and grazing; and in Wisconsin on various forage diseases. By 1935 the experiments in Indiana and Massachusetts had been completed, but coöperation continued in the six other States. In Ohio a long-time independent Federal timothy-breeding investigation has been brought into State coöperation.

The Great Plains Area

The first Federal-State coöperation on the Great Plains was at the Nebraska Station, where investigations of pasture, meadow, and forage crops were conducted from 1897 to 1903 and summarized (121—59) under joint authorship. Beginning about 1905 the Office of Dry Land Agriculture began to establish rotation and tillage experiments on independent Federal and coöperating State stations throughout the area. Such forage crops were included in the rotation as fodder or hay plants or green manures. The results will be found in many of the publications cited in the discussion of

Rotation and Tillage Experiments under general Crop Production. As these stations developed varietal tests, a limited number of forage crops were included, especially where livestock production was part of the station program. In 1924 the Office of Forage Crop Investigations published a summary of the relations of forage crops to agriculture in the northern Great Plains (90—1244). This included results obtained on those and other stations in North Dakota, Montana, and Wyoming. In a similar way the Plant Industry Division of Western Irrigation Agriculture also tested forage crops and especially pastures on its experiment stations on Federal reclamation projects. Some of these were in coöperation with State stations but apparently none was in coöperation with the Office of Forage Crop Investigations.

Experiments in growing various roots as feed crops for livestock were conducted by the Office of Forage Crop Investigations from 1920 onward in coöperation with the Kansas, Montana, North Dakota, and Oregon Stations (92—416), the results being published in 1934. A popular discussion of the same subject (91—1699) was jointly authored by the Division of Forage Crops and Diseases and the Animal Husbandry Division of the Bureau of Animal Industry.

In Kansas, extensive Federal-State coöperation in forage-crop studies began in 1913 on the Fort Hays Branch Station. Results obtained from 1913 to 1920 were published by the State (42—225) and from 1913 to 1928 in comprehensive form by the Federal agency (92—410). The coöperation continues. In Montana, coöperation by the Federal Division of Forage Crops and Diseases was directly with the Division of Dry Land Agriculture, while through both of them there was coöperation with the State at the Judith Basin Substation. Results were summarized under Federal authorship and published by the State for perennial crops (60—152) and annual crops (60—153) in 1923 and by the Federal agency for all forage crops (90—1244) in 1924. A discussion of hard seeds in legumes (90—248) likewise contained Federal-State data from the substation. Experiments with dry-land pasture crops for hogs (90—1143) were conducted in a three-way coöperation by the Federal Divisions of Dry Land Agriculture and Animal Husbandry and the Montana Station.

In Texas, comprehensive experiments with dry-land forage crops

were begun nearly thirty years ago at Chillicothe on a local station which in 1915 became State Substation No. 12, the experiments accordingly becoming coöperative. Many of the results obtained at this station are discussed later under Forage Sorghum.

In Wyoming the Plant Industry Offices of Cereal Investigations and Dry Land Agriculture have conducted extensive experiments on the Archer and Sheridan Substations in coöperation with the State and with unofficial coöperation from the Office of Forage Crop Investigations. Forage results were included in the comprehensive publication (90—1244) issued in 1924 and those from the Archer Substation were published by the State (148—195).

In 1931, formal or informal coöperative studies were listed by the Division of Forage Crops and Diseases in eight of the Great Plains States. By 1935, comprehensive and formal coöperation was limited to the Kansas, Nebraska, and Texas Stations.

Great Basin and Pacific Coast States

Most of the coöperative experiments with forage crops in these two areas have been conducted in coöperation with the Oregon and Washington Experiment Stations. This was especially true of the early studies by the Office of Farm Management, previously mentioned. Farm practices with forage crops were studied by that Office in coöperation with the Oregon and Washington Stations, with publication of results (121—94) in 1905. A coöperative study of range management in Washington (121—75) was published in the same year. A similar coöperative study of field-pea production in Washington was published by the State (142—99) in 1911.

An investigation of pastures and grain crops for hogs in the Pacific Northwest (90—68; 91—599), begun in 1909 and published in 1914, was coöperative with only the Washington Station.

In Oregon, a coöperative program of forage-crop investigations for western Oregon was begun at the State Station about fifteen years ago, and continues. Jointly authored publications on the common vetch (78—213) and on alfalfa (78—246) appeared in 1925 and 1929, respectively.

In Washington coöperative forage-crop experiments were begun in about 1918 at the State Station at Pullman, the Adams County Branch Station at Lind, and a special branch station for forage

crops conducted at Waterville. This special station was established in 1915 by Douglas County and the State Station. From 1918 until its discontinuation ten years later it was maintained in coöperation with the Federal Office of Forage Crop Investigations. Experiments with wheat as a forage and grain crop were published co-operatively (142—327) in 1928.

Minor coöperation in Idaho is presented under clover and similar work in California under range investigations and alfalfa, respectively.

GRASSES

Grasses constitute the most numerous and extensively distributed of all forage plants. For present purposes the coöperative investigations of grasses may be discussed under three heads, namely, forage sorghums, pasture and hay grasses, and range investigations.

Forage Sorghums

Substantially all the grain-producing sorghums are used also for forage (90—1260) and therefore the coöperative activities recorded under grain sorghums in the section on Cereal Crops are pertinent to forage sorghums as well. The diseases, also, of both groups are the same. Numerous experiments, however, have been conducted by forage-crop specialists from the forage point of view, and these are discussed below.

Early experiments by the Office of Forage Crop Investigations in coöperation with the Kansas and Texas Stations from 1913 to 1915 covered new sorghum varieties (90—383). In Texas independent investigations were begun on rented land at Chillicothe more than twenty-five years ago. In 1915 a larger tract was purchased by the State. It was called Substation No. 12 and the experiments thereafter were conducted in Federal-State coöperation. Early results (90—383) were mentioned above. Studies of experimental methods in growing sorghums (41—37:628) followed, and studies of the flowering and fertilization of sorghums, conducted in 1932, were published under joint authorship (41—49:123).

At the Big Spring Substation in Texas, part of the experiments conducted from 1923 to 1925 were in coöperation between the Federal Bureaus of Animal Industry and Plant Industry and the

Texas Station. At the Tucumcari Substation in New Mexico, studies of feeding dry-land crops to steers (92—30) and feeding sorghum silage and fodder to calves (92—43) were conducted jointly by the Federal Divisions of Animal Husbandry and Dry Land Agriculture and the New Mexico Division of Animal Husbandry.

Pasture and Hay Grasses

An early study of native pasture grasses (90—201) was presented in 1915 under joint authorship of the Plant Industry Office of Farm Management and the Bureau of Chemistry. An early Federal-State investigation of bluegrass pastures made in Virginia from 1908 to 1912 was jointly authored (139—204). A statistical study of pasture lands (90—626) was compiled by the Federal Office of Farm Management and the Census Bureau from census data of 1910. Recently, data for a pasture handbook (97—194) were prepared by the specialists of three Federal bureaus, Animal Industry, Dairy Industry, and Plant Industry.

In the Great Plains, an extensive study of the introduced crested wheat grass, compared with other dry-land grasses and pasture crops, was conducted coöperatively by the Divisions of Forage Crops and Dry Land Agriculture with the Montana, North Dakota, and Wyoming Experiment Stations (92—307) and issued under joint authorship of the first three agencies in 1932.

During the years 1926 to 1929, the Division of Hay, Feed, and Seed in the Federal Bureau of Agricultural Economics coöperated with the Division of Agronomy in the Nebraska Station in a study of prairie hay (64—60) and also of the identification of prairie hay grasses by their vegetative characters (64—65), both issued in 1932.

In Minnesota, the Station Divisions of Agronomy and Soils collaborated in studies of reed canary grass (55—252) and its use for meadows and pastures (55—263), the former acknowledging information obtained from officials of various State Stations.

Studies of the sorghum hay grasses, Johnson grass, and Sudan grass, have been made coöperatively in several States. The Federal Divisions of Forage Crops and Farm Management conducted a study of the production of Johnson grass for meadows and pastures (91—1597). A study of the new and promising Sudan grass

was made by the first-named Division in coöperation with several States (90—981) and issued in 1921. Sudan grass as an emergency pasture crop on light soil was the subject of Federal-State investigations at the Michigan Station recently (52—240). A long-time Federal-State study of this grass in Texas from 1913 to 1926 was authored jointly (88—396) in 1929. A study of Sudan grass as a hay, pasture, and silage for dairy cattle was conducted coöperatively at Woodward, Oklahoma, from 1928 to 1931, by the Federal Bureau of Dairy Industry and the Oklahoma Station (92—352).

In protection of grasses the research of the Division of Cereal Crops and Diseases in the diseases of cereals often was pertinent to and sometimes coöperative with the Division of Forage Crops and Diseases (41—24). In 1928, the then Division of Vegetable and Forage Diseases, in coöperation with the Wisconsin Station, published on strains of *Rhizoctonia* affecting golf grasses (41—36).

Range Investigations

Studies of the grasses and other forage plants of the western range were begun immediately after the Federal Division of Agrostology was formed in 1895. Most of the early surveys, however, were non-coöperative. With the turn of the century coöperation was developed. The reseeding of depleted range lands (121—117) appeared in 1907, with State station assistance acknowledged. In 1907, also, studies of the life history and forage value of important range plants were begun, in coöperation with the Forest Service, and in 1917 were published (90—595).

The Great Plains.—General surveys and minor experiments on range conditions were made in the Great Plains from Texas (121—13) northward. The use of native vegetation as an indicator of the agricultural value of the land (121—201) was published in 1911, with some Federal interdivisional coöperation.

In Colorado, the Station Departments of Botany and Animal Husbandry coöperated in a study of different systems of grazing upon western wheat-grass range (19—377), published in 1931. In Kansas, the Federal Division of Forage Crops and Diseases has recently coöperated with the State at the Fort Hays Branch Station on methods of reëstablishing buffalo grass on cultivated land in the Great Plains (93—328). In North Dakota, the Federal Division of

Dry Land Agriculture, at the Mandan Field Station, has had the coöperation of the State Division of Animal Husbandry in long-continued studies of differential grazing of controlled native range.

Western basin and desert areas.—Federal-State investigations of range conditions have been made in Arizona, California, and the Pacific Northwest, especially Washington. Forage conditions in the northern part of the Great Basin (121—15) and in the Pacific Northwest (121—38) were early Federal studies of 1901 and 1902, with only informal assistance from the States. Range management in Washington was studied (121—75) in 1901—03 by the Federal Division of Farm Management in coöperation with the Washington Station.

California Station: Through a coöperative arrangement, a member of the University of California Agricultural Experiment Station staff was released to the Federal Division in 1901 to make a survey of the plants and conditions on the stock ranges of north-western California (121—12). In about 1925, the Federal Forest Service and the Division of Forestry at the California Station coöperated in a comprehensive study of the range grasses of California (8—430), published under joint authorship, and with previously accumulated data and illustrations of both agencies fully used. Further critical analyses of grazing problems are under way in coöperation between Federal and State forestry, grass, livestock, extension, and regulatory officials. A study of the carbohydrate metabolism of a range needle grass (*Stipa*) was conducted in 1926—27 and prepared jointly by the station and the Riverside Junior College (31—5:61). The establishment and succession of vegetation on different soil horizons, authored jointly by the Station Division of Forestry and the Federal Forest Service (31—5:155), was issued in 1931.

Arizona Station: In 1900, an area of fifty-eight square miles in the Santa Rita National Forest was set aside by Presidential proclamation, as the Santa Rita Range Reserve, for experimental purposes. The investigations were conducted through a three-way coöperation of the Forest Service, the then Federal Division of Agrostology, and the Arizona Experiment Station in the problems of range management (121—4). The major problems were to demonstrate the possibility of recovery under controlled grazing,

to determine the time required for such recovery, and to increase carrying capacity by reseeding and the introduction of new plants. Each of the successive coöperative publications (121—67, 177; 90—367) summarized the results from the beginning, the last from 1903 on through 1914.

New Mexico Station: A study of "factors affecting range management in New Mexico," made in 1909—13, was noncoöperative (90—211). Recently, however, the influence of precipitation and grazing on a black grama-grass range was studied coöperatively by the Forest Service and the New Mexico Station, on the Jornada Range Reserve (92—409). Assistance was received from the Plant Industry Seed Division, the Weather Bureau, and the University of Chicago.

Protection of the range.—Protection of the range has been primarily against insects and rodents rather than fungus diseases.

In Arizona the State Station and the Federal Bureau of Biological Survey studied the life history of the kangaroo rat, the results being published both in the Federal series (90—1091) and by the State (3—1), each publication showing that it was also a certain number in the other agency's series. A coöperative investigation was made by the Federal Bureaus of Biological Survey and Forest Service, the State Station, and the Carnegie Institution, from 1916 to 1922, of the damage done to range grass by prairie dogs (90—1227).

In Colorado and Montana the Federal Bureau of Entomology and the State stations made coöperative studies of the history, habits, and control of the Mormon cricket. The Federal bureau supplied poison and apparatus because invasions originate on the public domain, the States and counties furnished supervision, and the ranchmen supplied the labor (92—161).

LEGUMES

Legumes, or members of the pea family, are a very diverse group. Some are annuals, such as the cowpea, field pea, most lespedezas, soybean, and vetch. Others are biennial, as for example alsike clover and sweet clover, or perennial, as are alfalfa, red clover, kudzu, etc. They have a double function, serving both as forage crops and as soil builders through the fixation of nitrogen.

Hard seeds, which do not germinate promptly, are common in many legumes and have been the subject of much study. Several of the coöperative investigations reported under alfalfa, clover, and other legumes covered this problem, especially one made in Montana (60—248). Very recently the Bureaus of Agricultural Engineering and Plant Industry have issued jointly a comprehensive discussion of studies of mechanical scarifiers (93—345).

Legumes were included, of course, in the coöperative activities discussed under general forage production. Results of coöperative investigations concerned especially with legumes are presented below. Alfalfa, being the most important and widely distributed, has received major attention.

Alfalfa

Federal-State coöperation in alfalfa investigations has flourished in many States and for many years. It has covered both production and protection. Often the studies have been concerned with temporary or local problems, but the later studies cover problems requiring long-range research.

Production activities.—Because it has been introduced into all the diverse regions of the United States, the coöperative production studies of alfalfa will be presented by major climatic and topographic regions.

Southern and northeastern States: in the southern States, Federal-State investigations of alfalfa are being conducted chiefly at the Stoneville and West Point Substations in Mississippi and at the Statesville Substation in North Carolina. Early experiments in Virginia (139—207), published in 1914, were coöperative between the State Department of Agriculture and the Experiment Station. In the north-central and northeastern States, alfalfa varietal and adaptation studies are being conducted in Iowa, Massachusetts, and Ohio, especially. In New Jersey, a study of yields, culture, and production costs, issued in 1925, was coöperative between the Station Divisions of Agronomy and Farm Management (68—408) and the State Department of Agriculture.

Great Plains: In this area, coöperative experiments on varietal adaptation, and especially winter hardiness, have been conducted with most of the States. Winter-resistance studies are discussed

below, under Protection. Early Federal-State coöperation in Colorado, on conditions affecting seed yields (19—257), was published in 1920. In Kansas, station interdivisional coöperation in studies of the time of cutting alfalfa (43—15) was jointly authored in 1925 by the Divisions of Agronomy, Animal Husbandry, and Chemistry.

In Nebraska, the Federal Bureaus of Plant Industry and Agricultural Economics coöperated with the Experiment Station in studies of the quality of alfalfa hay in relation to curing (92—235), in connection with the Federal hay grades. The Station Department of Dairy Husbandry and the Federal Bureau of Dairy Industry coöperated in determining the vitamin content of alfalfa hay naturally and artificially cured (64—62), a discussion of which was published in 1932.

In South Dakota, early Federal-State coöperation in alfalfa production, in 1909—11, was made public by the State (86—133), as were also the results of recent minor coöperation with the Wyoming Station (148—195) at the Archer Substation.

Great Basin and Pacific Coast: At the Utah Experiment Station, the local representative of the U. S. Weather Bureau coöperated in a publication on the relation of weather to alfalfa-seed production (136—171) in 1914. Recent Station studies on this topic (136—226) acknowledged assistance from the Station Division of Entomology, the county commissioners of Ouray and Uintah Counties, and the superintendent of the Federal Indian Agency in that section. In Oregon, recent Federal-State investigations in the Willamette Valley (78—246) were published in 1929. In California, no Federal coöperation with the State Station is recorded, but two Plant Industry Divisions, Forage Crops and Western Irrigation Agriculture, coöperated at the Yuma Field Station from 1919 to 1925 on irrigation experiments with alfalfa, jointly authored (90—1418).

Fungus and bacterial diseases.—The fusarium wilt of alfalfa, caused by a physiologically specialized variety of a *Fusarium* species, was the subject of Federal-State coöperative research in Kansas, Nebraska, and Wisconsin from 1926 onward, often in connection with studies of winter injury. It was begun by the former Federal Division of Vegetable and Forage Diseases.

At the Kansas Station coöperative studies of the causal organism

were begun in 1926 and published (41—37:419) in 1928. The relation of temperature and soil moisture then was investigated (41—40:97). Additional hosts of this wilt disease were discovered (41—39:351).

At the Nebraska Station, the coöperative studies covered first the relative susceptibilities of alfalfas to wilt (64—52), published in 1930 under joint authorship. This was followed by research on the wilt and cold resistance of selfed lines (64—76).

At the Wisconsin Station, similar coöperative studies were made and a bacterial wilt was discovered to be associated with winter injury (41—37:189, 445). Later, coöperation was resumed at the Wisconsin Station by the Federal Division of Forage Crops and Diseases and the resistance of alfalfa to this wilt was studied (41—48:1085).

At the California Station, arrangements were made by the Federal Division named above to begin formal coöperation on July 1, 1929, at the Citrus Experiment Station, Riverside. The research covered alfalfa diseases of unknown causation, occurring in southern California and presenting symptoms which resembled those of alfalfa wilt. Under the coöperative agreement, the California Station furnished the necessary land, about five acres, field facilities, and office and laboratory space, and also supplied \$1200 annually for field expenses. The Bureau of Plant Industry provided a plant pathologist and his field and other necessary expenses. A publication on the effect of environment and cultural conditions on the so-called dwarf disease was issued (41—47:351) in 1933 and the coöperation concluded soon thereafter.

Insect pests.—*Alfalfa weevil*: The alfalfa weevil, introduced into Utah about twenty years ago, and since spread across Nevada to California, has been the cause of some coöperative study. In Utah, the Experiment Station Department of Veterinary Science coöperated with the Federal Bureau of Entomology in tests of the feeding value of alfalfa hay after treatment with calcium arsenate (136—223), with publication in 1930. In Nevada, a study of control by spraying, representing coöperation between the Nevada Station and Extension Service, the State Quarantine Office, and the Federal Division of Cereal and Forage Insects, was published (66—108) in 1925. In Colorado, recent studies were coöperative

between the Station Division of Entomology and the State Entomologist (19—399).

In California, the Station Division of Entomology published (8—567), in 1933, an account of the weevil, in which generous assistance was acknowledged from the Federal Bureau of Entomology, the Alameda County Commissioners, and the Station Division of Agronomy.

Alfalfa aphid: In parts of southern California, the alfalfa plant louse is injurious. Federal studies of aphid control by burning (93—287) and the general problem (93—307), both published in 1933, resulted.

Leaf hopper: A coöperative investigation by the two Federal Divisions, Cereal and Forage Insects and Forage Crops and Diseases, on the nature of the sheath material in the feeding punctures of the alfalfa leaf hopper and the potato leaf hopper was published (41—47:475) in 1933.

Winter injury.—From 1905 to 1910, the Plant Industry Office of Forage Crop Investigations and the North Dakota Experiment Station conducted a coöperative investigation of the cold resistance of alfalfa (121—185) which was issued under joint authorship. In the middle twenties, increasing winterkilling of alfalfa in the north-central States brought about an extensive Federal-State coöperative investigation in Kansas, Nebraska, and Wisconsin, beginning in 1926. The problem was associated with the occurrence of wilt diseases caused by fungi and bacteria, previously discussed.

Studies in coöperation with the Kansas Station, from 1926 to 1928, already have been cited under alfalfa wilt. A third and later study of some factors in winterkilling of alfalfa (41—39:263) was issued in 1929, and a fourth, a study of root injury resulting from freezing (41—40:121), was in coöperation with the Wisconsin Station also.

In 1927, coöperation was begun with the Nebraska Station in investigation of conditions affecting the winter hardiness of alfalfa. The published contributions have covered relative susceptibility to cold and to wilt disease (64—52); hardiness of two-year alfalfa, jointly authored (41—43:931); hardiness studies, also of joint authorship (41—44:429); influence of light, temperature, and soil moisture on hardiness (41—46:483); determination of



hardiness by enzymatic responses (41—48:219); and cold and wilt resistance of selfed lines (64—76);—all published between 1930 and 1934.

The coöperative studies at the Wisconsin Station covered winter injury with reference to bacterial wilt (41—37:189), the wilt as influenced by winter injury (41—37:445), and root injury resulting from freezing (41—40:121), published from 1928 to 1930, the last-named in coöperation with the Kansas Station also.

Other Legumes

A sufficient number of coöperative studies have been devoted specially to clovers, sweet clovers, soybeans, and vetches to warrant special mention of them as well as of the general forage-crop studies already discussed. A coöperative study of harvesting soybeans and clover with combines and binders was conducted in the Corn Belt in about 1928 and authored jointly by three Federal Divisions—Cereal Crops and Diseases, Farm Management and Costs, and Agricultural Engineering—representing three different Bureaus, in coöperation with the Illinois and Indiana Stations (92—244).

Red and berseem clovers.—*Red clover*: A special study of the adaptibility of red clovers obtained from different foreign countries was made by the Federal Division of Forage Crops in coöperation with numerous State stations, from 1922 onward. The coöperating States in the first series of tests, from 1922 to 1925, in the North were Iowa, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin, and in the South, Maryland, Tennessee, and Virginia. For the second period, from 1926 onward, there were added Indiana and West Virginia in the North and Kentucky and Missouri in the South. The coöperative data obtained from 1922 to 1929 in all States were summarized (93—210) and published in 1932. The Kentucky data from 1922 to 1930 were issued by the State (45—318).

A study of the pollination of red clover by honeybees was begun by the Colorado Station in 1927, with financial aid from the Office of the State Entomologist. It was completed (19—391) in 1930, in coöperation with the Federal Division of Forage Crops.

Clover-seed production was investigated coöperatively at the

Idaho Station. A coöperative Federal-State study of seed setting at the Illinois Station was published (41—39 :229) in 1929.

Protection from diseases has had little coöperative attention. Clover diseases, especially mildew, were investigated coöperatively at the Indiana Station. In Tennessee, Federal-State research in clover anthracnose was published (92—28) in 1928, by the Federal agency.

Berseem or Egyptian clover: The Federal Division of Forage Crops began tests of berseem at the Federal Yuma Field Station in California in 1918 and continued them for several years. In 1921, informal coöperation was arranged with the Division of Agronomy at the California Station for tests on the Branch Station at El Centro in the Imperial Valley. Thereafter, arrangements were made with the Imperial County farm advisor, for tests by farmers in the Imperial Valley. A preliminary report of these coöperations was published by the State (8—389) in 1925.

Sweet clover.—Early coöperative experiments in the production of sweet-clover seed at the Iowa Station, from 1916 to 1918, were published (90—844) in 1920, under joint authorship. Thereafter, in several States, there was Federal-State coöperation in sweet-clover investigation. Some special aspects of sweet-clover growing are studied at the Massachusetts Station, in States of the Great Plains from Oklahoma to North Dakota, and also at the Washington Station. Experiments on the use of sweet clover to renovate depleted range areas are conducted in coöperation with the Forest Service at forest experiment stations in Colorado and Utah.

Soybean.—Some Federal-State coöperation in tests of soybean varieties for hay and seed production has existed for several years. In North Carolina, the Federal Division of Forage Crops has coöperated in tests of both soybeans and cowpeas at the Statesville Substation, and the State published results (72—241) in 1919. The North Carolina Department of Agriculture, in 1920, published on farm practices with soybean (*North Carolina Department of Agriculture Bulletin* 267), under the authorship of former Federal-State extension workers.

In the widespread Federal-State coöperation on forage crops, begun some five years ago, soybeans are investigated at many south-

ern stations, particularly Louisiana, Mississippi, and the Carolinas. In the northern States they are given special coöperative attention in Iowa, Massachusetts (49—309), Ohio, and Wisconsin, in the latter at the Spooner Substation where tests of far northern adaptation are made. Part of the recent Iowa study has involved the Station Division of Agricultural Economics also (39—309).

Vetches.—At the Oregon Station, coöperative studies of the Hungarian vetch were published by the Federal agency (90—1174) in 1923. Similar studies of the common vetch and its varieties were issued (90—1289) in 1925.

A study of a bruchid (or lariid) weevil affecting seeds of the hairy vetch was issued jointly by the Federal Bureau of Entomology and the Food and Drug Administration, the agents of the latter obtaining the material at various points (41—46:739).

Protection from insects.—The Federal Division of Cereal and Forage Insects has maintained a field laboratory in California since 1912. No coöperation has occurred in any of its studies of insect pests of legumes. Since its removal to Sacramento in 1920 it has maintained contacts with the State Department of Agriculture.

In the Federal-State coöperation in Illinois on forage-crop production, a study was made in 1926—27 of the symptoms produced on legumes by the leaf hopper (41—38:649), in coöperation also with the State Natural History Survey. In the coöperative Kansas study of the causes of alfalfa wilt, the infection of many other leguminous plants by this organism was determined (41—39:351). A four-year study by the Federal Divisions of Cereal and Forage Insects and Forage Crops and Diseases, begun in 1925, on leaf-hopper injury to legumes was published (41—43:267) in 1931.

The publications listed in Literature Cited at the end of this chapter which have been cited in this section on Forage Crops are: Nos. 3, 8, 19, 31, 39, 41, 42, 43, 45, 49, 52, 55, 58, 60, 64, 66, 68, 72, 78, 86, 88, 90, 91, 92, 93, 95, 97, 121, 136, 139, 142, and 148.

5. FIBER CROPS

THE PRINCIPAL FIBER CROP of the United States is cotton. Less important fiber plants are fiber flax, hemp, and broomcorn, this latter being properly but not usually classed as a fiber crop.

OFFICIAL AGENCIES

The large total number of official agencies, especially Federal units, which have had some part in fiber-crop investigations is out of proportion to the size of this group of crop plants. On the other hand, the volume of results obtained in coöperation has been proportionately small, considering the importance of the cotton crop alone.

Federal Agencies

A section of Fiber Investigations was created in the Federal Division of Statistics in the U. S. Department of Agriculture in 1889. In 1890 it was made an independent Office and so remained until its work was assigned to the Division of Botany in 1898. It conducted no coöperative enterprises. In about 1901, a new Office of Fiber Investigations was established in the Bureau of Plant Industry, where it has remained, independently or in connection with successive cotton units, to the present time. It has conducted limited experiments, independent or coöperative, on fiber flax and hemp, discussed below. In recent years it also established minor coöperation with official agencies in the Canal Zone, Puerto Rico, and the Philippines in the study of abaça (Manila hemp), henequen, sisal, and other tropical fibers.

In 1901, a Cotton Breeding Laboratory was established in the Bureau of Plant Industry. In about 1909 the work with cotton was placed in an Office of Crop Acclimatization and Adaptation. Between 1923 and 1929, its name was changed to Office of Cotton, Rubber, and Other Tropical Plants, to remain so until a complete reorganization took place in 1935, when there emerged a Division of Cotton and Other Fiber Crops and Diseases. During the last several years before the reorganization there also was an independent Division of Egyptian Cotton Breeding, now merged in the larger Division named.

Other Plant Industry Divisions, also, were concerned. The Division of Dry Land Agriculture has conducted varietal and cultural experiments with cotton, as well as rotation and tillage tests, at its field stations at Big Spring and Dalhart, Texas, and Tucumcari, New Mexico. The Division of Western Irrigation Agriculture has carried on similar coöperative experiments at its field station at

San Antonio, Texas (90—279 and 668), and the Yuma Field Station, at Bard, California.

In the Bureau of Entomology, there long was a Division of Southern Field Crop Insects, a Division of Tropical, Subtropical, and Ornamental Plant Insects, working in the far Southwest and including cotton there, and likewise a Division of Boll Weevil Control. In 1928 there was established a Division of Cotton Insect Investigations, and still more recently an additional Division of Pink Bollworm and *Thurberia* Weevil Control, the latter concerned primarily with quarantine measures. In the Bureau of Agricultural Economics, the Division of Cotton Marketing has long been engaged on technical studies of the cotton fiber with reference to grade and tenderability. This has required coöperative research on spinning qualities of fibers from different varieties and different conditions of production. In this work, they have had coöperation from the Division and Bureau of Agricultural Engineering in the designing and installation of apparatus and the construction of buildings.

The diseases of cotton were investigated by the long-established Division of Vegetable Physiology and Pathology from 1891 to 1901 and by the Plant Industry Division of Cotton, Truck, and Forage Crop Diseases from 1909 until all disease studies were transferred to crop divisions in the recent reorganization. Diseases of flax and broomcorn have been investigated by the Division of Cereal Crops and Diseases, which is charged with the investigations of seed flax, grain sorghums, and broomcorn.

State Agencies

In the State stations these fiber crops are handled by the agronomy or farm crops division, their insect pests by the division of entomology, and their fungus and bacterial diseases by the division of plant pathology. The technical and spinning tests of cotton fibers, in important cotton States, are handled by a separate textile division or by a textile school in the State college of agriculture, as in the Carolinas.

COTTON

The work done on cotton may be separated into three phases, namely, production, quality studies, and protection. With the ex-

ception of the activities of the Division of Cotton Marketing in determining quality of fiber, the instances of coöperation are sporadic rather than parts of a continuing program.

Production

As early as 1893, the U. S. Weather Bureau made a comprehensive report on the climatology of the cotton plant (132—8). It was prepared by the director of the coöperative Alabama Weather Service and acknowledged useful information received from many Federal-State weather services and State agricultural experiment stations.

The Federal Plant Industry Office charged with cotton investigations was noncoöperative and therefore the coöperation in production activities is very meager. The newly organized Division is thoroughly coöperative, and a very far reaching Federal-State program has been organized and now is in operation. The following items refer to activities prior to its creation.

Southern States.—The experiments with cotton on stations of the Federal Divisions of Dry Land Agriculture and Western Irrigation Agriculture already have been mentioned. Within recent years the work done on the Lawton and Woodward Field Stations of the first-named Division has been brought into coöperation with the Oklahoma Station, which has published the Lawton results (77—209) for the years 1916 to 1931, inclusive, acknowledging the coöperation of the "Cotton Division." Similar joint experiments on single-stalk culture (90—279) and nurse planting (90—668) were conducted on the San Antonio Field Station of the Division of Western Irrigation Agriculture, some twenty years ago.

In 1917, the Office of Farm Management and Office of Forage Crop Investigations coöperated in a study of farm practices in cotton culture (90—519). In 1924, the Seed Laboratory of the Federal Bureau of Plant Industry conducted experiments on the germination of cotton seed, checked by field tests on stations of three other Federal Divisions and of the Texas Station (41—28:285).

The Division maintained a testing station on the Pima Indian Reservation near Sacaton, Arizona, through the coöperation of the Office of Indian Affairs in the Department of the Interior. Among

the early studies was one on the summer irrigation of Pima cotton (41—23:927), in 1920.

A report on cotton experiments conducted coöperatively by the Federal Division and the South Carolina Station at the Pee Dee Substation, at Florence, from 1923 to 1925 was published by the State (84—225). A survey of community production in relation to yield and staple in 1931—32 was issued (85—48) under joint authorship.

The Division of Soil Fertility, then in the Federal Bureau of Chemistry and Soils, coöperated with State stations in testing fertilizers and fertilizer placements on various crops, including cotton. One such study of the effect of synthetic nitrogen and concentrated fertilizers, conducted in coöperation with the North Carolina Station, was jointly reported (72—266) in 1929, and a second (92—452) in 1934, the latter containing coöperative data from the Georgia and South Carolina Stations also.

A recent study of cotton production in Egypt, conducted by the Division of Foreign Agricultural Service in the Bureau of Agricultural Economics with assistance from the Egyptian Government, was issued (92—451) in 1934.

The new Division of Cotton and Other Fiber Crops and Diseases has organized a program of definite research on cotton in coöperation with the State stations in Alabama, Arkansas, California, Georgia, Louisiana, Mississippi, New Mexico, North Carolina, South Carolina, Tennessee, and Texas. Recent coöperative studies of cotton spacing in the Mesilla Valley of New Mexico have been published (69—219) by the State.

California activities.—Attention has been given to the history of cotton growing in California. In 1915, a discussion of Durango cotton in the Imperial Valley (90—324) gave a history of cotton growing in that district, and in 1917 a summary of the extension of cotton growing in California was published (90—533), both without coöperation. In 1930, an official of the Federal-State Crop Reporting Service prepared a discussion of California cotton, including the history of cotton growing in the State, which was published by the State Department of Agriculture (12—19:769).

Large Federal expenditures and activities in cotton production, by the Bureau of Plant Industry, have occurred in California dur-

ing the past fifteen or twenty years. Minor activities have been conducted by the Federal Bureau of Entomology, which will be discussed under protection. Coöperation in the cotton-production activities has been only sporadic and incidental. In only one minor instance has it been coöperative with the State Station.

The former Division of Cotton, Rubber, and Other Tropical Plants has maintained three separate field stations or acclimatization gardens in California. The Cotton Field Station near Shafter, in the San Joaquin Valley, was established in 1921. The 80 acres occupied are owned by Kern County and leased at a nominal rental by the Board of Supervisors. The Board also furnishes buildings, water, power, and equipment and sells the surplus cotton. The receipts run as high as \$2000 to \$3000 per annum, and are applied to Station expenses. The Division has supplied additional buildings and an annual budget of nearly \$25,000. The Yuma Acclimatization Garden near Bard, in Imperial County, was within the Fort Yuma Indian Reservation and occupied about 640 acres set apart by the Office of Indian Affairs of the Department of the Interior for this purpose in 1919. The Division furnished buildings and equipment and an annual budget of about \$12,000, of which a good part was spent on cotton. This Garden was closed in the reorganization. The San Diego Acclimatization Garden was located at Torrey Pines in San Diego County. It was established in 1923 on 174 acres of land owned by the city of San Diego and leased at a nominal charge to the Division, which furnished buildings and an annual budget of about \$10,000, not all applied to cotton experiments. This Garden also was closed.

The Federal Division of Western Irrigation Agriculture maintains the Yuma Field Station at Bard, in Imperial County, on the Yuma reclamation project of the Bureau of Reclamation of the Department of the Interior, which withdrew from homestead entry in 1910 the 160 acres of land occupied by the station, and also furnished a house and an office building. Other buildings and equipment were supplied by the Division from 1915 onward, as well as an annual budget of some \$15,000. Most of the work done is with cotton.

The former Division of Egyptian Cotton Breeding conducts cotton investigations on the last-named station. In 1931, it began

cytological and genetic studies at the Rubidoux Laboratory of the Citrus Experiment Station at Riverside, in coöperation with the California Station. This research continues under the new organization.

In recent years, much emphasis has been given to the production of only a single variety in a given community, in order to prevent mixing and lower quality. This was discussed for the San Joaquin Valley (94—357) in 1925. In that year also the State legislature enacted a law (90—1467) protecting organized one-variety communities or districts by making it unlawful to plant any other than the designated variety of cotton. Most of the cotton areas in the Coachella (90—1467), Imperial, and San Joaquin Valleys, and the Kern-Fresno Basin, were included in such districts. County ordinances are passed by the Board of Supervisors and enforcement is by the County Agricultural Commissioner.

Fiber Quality

The invasion of the Mississippi delta area by the boll weevil seriously disrupted the production of Sea Island or true long-staple cottons and occasioned anxiety and loss to spinners. An Office of Cotton Handling and Marketing therefore was established in the Bureau of Plant Industry and an investigation of the situation begun. With the transfer of all marketing functions from Plant Industry to an independent Office of Markets in 1913, this Office of Cotton Handling and Marketing was administered jointly by the two agencies for a time. With the establishment of the Bureau of Markets in 1917 a Division of Cotton Marketing was created, and was continued to the present time in the Bureau of Agricultural Economics, established in 1923. This Division has coöperated extensively with State agencies and with the Bureaus of Plant Industry and Agricultural Engineering on problems of cotton-fiber quality.

Cotton-Belt States.—From about 1910 onward, the Office of Cotton Handling and Marketing, Bureau of Plant Industry, conducted spinning tests and other quality studies of long-staple cottons grown in upland areas and of upland cottons with relatively long staple, in coöperation with the Textile Departments or Schools of the Mississippi and North Carolina Agricultural Colleges and

the South Carolina College at Clemson (90—68). Under the joint auspices of Plant Industry and Office of Markets a study was made of long-staple upland cottons (90—121) in 1912. Again in 1922 the two agencies coöperated in a study of Meade, a new extra-staple upland cotton (90—1030).

Many investigations were between only the Federal Division of Cotton Marketing and State agencies. In 1919, it coöperated with the Texas Station Department of Plant Breeding and the Texas Extension Service in a study of the staple of Texas cotton (88—266). In 1923 were published the results of spinning tests coöperative with the North Carolina and South Carolina Agricultural Colleges (90—1135 and 1148). In 1927 appeared the results of manufacturing tests made by the Federal Division in coöperation with the South Carolina (Clemson) College (90—1488). In coöperation with the North Carolina Textile School and Station, the Division studied the relation of fiber characters to yarn quality (73—33), published by the Station in 1928. In 1931, appeared a jointly authored discussion of the source and care of planting seed in relation to staple length for the season of 1929—30, in which the Plant Industry Division was included (73—42).

In about 1930, the agricultural engineers, State and Federal, were brought more definitely into the problem of the effect of gin construction and operation on fiber quality. Mississippi and Texas, as well as the Carolinas, took part in the common program. Following previous extensive independent tests (91—1465) by the Division of Cotton Marketing, the Federal Division of Agricultural Engineering collaborated with manufacturers in Alabama and Georgia and with the Clemson Agricultural College in South Carolina in tests of the engineering features of ginning under different conditions and with long-staple and short-staple cottons (92—396). In Mississippi, comprehensive coöperative studies of harvesting, drying, and ginning were made at the Delta Branch Station in 1930. A coöperative ginning laboratory was erected in 1931 on funds specially appropriated therefor by Congress. The collaboration of the engineers is discussed more fully in the chapter on Agricultural Engineering.

Southwestern States.—The postwar depression in agriculture having lowered prices of the long-staple cottons grown in Arizona

and California, and used chiefly in the tire trade, the Division of Cotton Marketing and the Plant Industry Division of Crop Acclimatization and Adaptation made a joint study of the utilization of Pima cotton for general textile purposes (90—1184), published in 1924. Preliminary studies were begun in 1933 on the use of roller gins with Pima cotton in Arizona, as a three-way enterprise of Plant Industry, Agricultural Economics, and Agricultural Engineering.

Protection

Cotton is affected by several fungus diseases and insect pests. There has been relatively little coöperation by official agencies in combating them. In the reorganized Federal program, however, provision is made for coöperative protection.

Root rot and wilt.—For many years cotton root rot has been a baffling problem in the western areas, especially in Texas. Experiments were conducted from 1928 to 1930 by the Texas Station in coöperation with the Federal Bureaus of Chemistry and Soils and Plant Industry (88—423). The University of Texas then was brought into the continuing coöperation. The relation of fertilizers to the root rot, authored by the Federal Division of Soil Fertility, was published (92—426) in 1934. Coöperative studies by the Plant Industry Divisions of Western Irrigation Agriculture and Cotton, Rubber, and Other Tropical Plants, at the San Antonio Field Station of the former, were authored jointly (41—43:681) in 1931.

California was so greatly interested in the possible destructive spread of the root-rot fungus from Arizona that the State Department of Agriculture published (12—19:501) an account of the disease, prepared by the Federal Division.

An early coöperation noted in the control of cotton wilt and anthracnose was between the former Federal Division of Cotton, Truck, and Forage Crop Diseases and the North Carolina Station and State Department of Agriculture, published (*North Carolina Department of Agriculture Bulletin* 264) in 1920.

Insect pests.—*Boll weevil:* The boll weevil invaded the United States from Mexico in 1892 and slowly spread across most of our cotton-growing areas. Many agronomic, chemical, entomological, and engineering activities resulted, but in few of them was there official coöperation. In 1917 and 1918, the Federal Bureaus of

Chemistry and Entomology collaborated in a chemical study of the cotton plant with reference to ingredients or conditions affecting boll-weevil attraction (41—13:345, 419). Data on boll-weevil poisoning, obtained by the Bureau of Entomology in coöperation with the Federal Division of Agricultural Engineering, were published (90—875) in 1920. Cotton was dusted with poison from airplanes and the results jointly authored (90—1204) by the Bureaus of Entomology, Agricultural Engineering, and Plant Industry, and the Army Air Service, in 1922. In 1929, the Bureau of Entomology and the Agricultural Extension Service collaborated in preparing a popular discussion of "cotton or weevils" (97—35).

In Florida, a State Plant Board has many of the regulatory functions usually exercised by a State department of agriculture. In 1922, this Board and the State Experiment Station jointly financed a study of an improved method of boll-weevil control (24—165). Federal-State coöperation occurred in South Carolina, where the station and the Bureau of Entomology published a progress report on boll-weevil control (84—223) in 1925, followed by a report on the biology of the weevil (92—112) in 1929.

Flea hopper: In South Carolina, a study of the cotton flea hopper (84—235) was made by the Experiment Station in coöperation with the Federal Bureau of Entomology, in 1926.

Pink bollworm: In 1913, a quarantine was made effective forbidding the importation of cotton or cottonseed from Mexico, but shortly afterward it was amended to permit their entry from northern Mexico, under permit and regulation, for milling purposes. On November 1, 1916, it was discovered that the pink bollworm was present in Mexico and a rigid quarantine was imposed. Unfortunately, more than four hundred cars of Mexican cottonseed had entered previously, and in 1917 bollworm infestation was found in Texas and later spread to Louisiana, New Mexico, and Arizona. Enormous sums have been expended to control and eradicate the insect and to prevent its introduction into California (90—1397).

The Federal Congress and the Texas Legislature collaborated in legislation to enforce a no-cotton zone as an eradication measure. There was full coöperation between the Federal regulatory units, the Federal Horticultural Board, and, since 1928, the Division of

Pink Bollworm Control of the Plant Quarantine and Control Administration and its successors, on the one hand, and the State departments of agriculture and other regulatory officers and units, on the other. The Bureau also carried its investigations of the bollworm into Mexico, with the assistance of the Mexican Government, and published its results (90—918) in 1921.

No Federal field station for bollworm control has been established in California, but a fumigation station for imported material was set up in San Francisco (90—1397). Effective quarantine inspection was maintained by both Federal and State officials (90—324). In 1929 and 1930, however, Federal quarantine agents were detailed to inspect cotton plantings in California, and in 1930 three gin-trash machines were taken to the State to supplement the work of the inspectors. This was done in coöperation with the Bureau of Plant Quarantine and Pest Control of the State Department of Agriculture, which also published two articles (12—19: 279 and 20:363) on the pink bollworm, contributed by Federal officials.

Studies of detecting bollworms in cotton seeds by the X-ray were made jointly by the Bureau of Entomology and the Texas Station (41—45:347) in 1931.

FIBER FLAX, HEMP, AND RAMIE

Fiber flax differs from seed flax, already discussed under Cereal Crops, chiefly in having been selected for long stems rather than for seed production. It is but little grown in the United States. Investigations of fiber flax have been conducted by the Federal Office or Section of Fiber Plants. The diseases are the same as those of seed flax, already discussed.

Fiber Flax

For many years the Office of Fiber Plants conducted experiments on fiber flax and hemp at the Michigan Station but collaboration was discontinued in about 1930. A special study of flax retting, made in coöperation with the Michigan Station Section of Bacteriology, was published under joint authorship (54—95) in 1928. A study of the time to harvest fiber flax (92—236), published in 1931, acknowledged also the coöperation of the Station Department of Chemistry in making the necessary analyses.

In the meantime, coöperation in fiber-flax breeding and cultural studies had been begun at the Oregon Station at Corvallis, and these are still in progress. These studies, recently, have included the physiological factors of the production of the fiber cells. Recently some activities in the adaptation of fiber flax in the southeastern States have been published (93—231) under joint authorship with the Virginia Station, and acknowledging assistance from the North Carolina Station.

Hemp

The principal experiments with hemp have been conducted by the Federal Division in coöperation with the Wisconsin Station during the past ten years or more. These are still in progress. For several years there was a minor coöperation with the Virginia Station in hemp improvement, but this has been discontinued.

Ramie

Commercial propaganda for the culture of ramie as a fiber plant assumes boom proportions in this country from time to time. In California, the State legislature, by act of March 31, 1891, created a Department of Ramie Culture in the State Board of Agriculture and authorized a State superintendent therefor. On request, the California Station conducted some plot experiments, analyzed samples, and provided exhibit material. Two annual reports were published in the *Transactions of the State Agricultural Society* for 1890 and 1891.

BROOMCORN

Broomcorn is a sorghum. It differs from other sorghum groups chiefly in the extremely elongated branches of the panicles, which become the familiar broomstraws of the household. The investigation of broomcorn has been an activity of the Federal Plant Industry Division of Cereal Crops and Diseases for the past twenty-five years, because the geographic location and the cultural methods essentially are those of the grain sorghums. The diseases also are the same.

The principal study of broomcorn has been made at the Woodward Field Station in Oklahoma, in coöperation with the Federal Division of Dry Land Agriculture, which maintains the station.

The accumulated data have been published twice (90—836; 92—51), the latter publication covering the years 1914—26. Studies on the inheritance of height, begun in 1919, were published (41—44: 13) in 1932. Since about 1930 this station has been conducted in coöperation with the Oklahoma Station also. Minor investigations were conducted on other stations operated by this Division in Kansas, New Mexico, and Texas. Some were carried on also in connection with grain-sorghum experiments coöperative with the Kansas Station.

The production and commercial handling of the broomcorn crop has been a coöperative concern of the Division of Cereal Crops and Diseases with the Division of Farm Management and Costs of the Federal Bureau of Agricultural Economics. Data obtained through studies covering twenty years at some Federal independent and coöperating stations in Kansas, Oklahoma, New Mexico, and Texas, and through coöperation with the Illinois and Kansas Stations, were summarized under joint authorship in popular form (91—1631) in 1930 and in a technical discussion of the economics of broomcorn production (92—347) in 1933.

The publications listed in the Literature Cited at the end of this chapter which have been cited in this section on Fiber Crops are Nos. 12, 24, 41, 54, 69, 72, 73, 77, 84, 85, 88, 90, 91, 92, 93, 94, 97, and 132.

6. OIL CROPS

THE MAJOR OIL CROPS in the United States are cotton, seed flax (oil flax), and peanut. The olive also produces oil, and an oil industry from the tung tree is developing in the southern States. However, cotton is grown chiefly as a fiber crop, and peanut chiefly as a nut crop for humans and a forage crop for swine. Seed flax, on the other hand, is grown almost entirely for linseed oil, the fiber being but little used, although fiber flax is grown wholly for fiber production. The olive is grown chiefly as a fruit crop in this country. Little or no coöperation has developed in the establishing of the tung-oil industry. For these reasons, the discussion of oil crops is based chiefly on seed or oil flax.

SEED FLAX OR OIL FLAX

The seed-flax crop is grown principally in the northern States of the Great Plains, namely, Minnesota, North Dakota, South Dakota,

and Montana. In the Federal setup, seed flax is allocated to the Division of Cereal Crops and Diseases, in the Bureau of Plant Industry, which covers both production and improvement and protection from diseases and other unfavorable environments.

Production and Improvement

The Federal agency named has been making extensive experiments in seed-flax production and improvement during the past twenty-five years, in coöperation with the agricultural experiment stations of some or all of the States mentioned. Minor experiments were conducted in the southern and southwestern States for shorter periods, sometimes with State coöperation and sometimes on field stations of other Federal units.

Federal-State coöperation.—The Federal Division of Cereal Crops and Diseases has coöperated widely with the Agricultural Experiment Stations of Montana, North Dakota, and South Dakota in production and improvement of cereals, including seed flax, especially from about 1910 onward. The early results were published mostly in State and Federal bulletins containing the results of experiments with all cereal crops and cited previously under Cereal Production and Improvement (pp. 522–524, above). Besides the two special publications described below, the coöperation with South Dakota resulted in a State bulletin (86—169) in 1916; that with North Dakota in a jointly authored State bulletin (74—178) in 1924 and a similarly written Federal popular bulletin (91—1747) in 1935; while that with the Montana Division of Agricultural Economics produced jointly a Federal popular bulletin on flaxseed production by power farming (91—1650) in 1930.

One of the interesting developments of the coöperation was a concerted Federal-State endeavor to increase the American flax acreage. A jointly written circular (94—341), *Seed Flax as a Farm Crop in 1925*, contained a general statement on flax growing, by the Federal author, and discussions of the place of flax in the cropping systems of Minnesota, Montana, North Dakota, and South Dakota, respectively, by a representative of each of those States.

The farm practice of growing seed flax in mixtures with wheat, oat, or barley was investigated coöperatively and the results published in a joint bulletin (92—133) in 1929. The five sections of

the bulletin were authored, respectively, by representatives of the U. S. Department of Agriculture, the Minnesota and Montana Agricultural Extension Services, and the North Dakota and South Dakota Agricultural Experiment Stations. At the end of the season of 1929, the same five agencies coöperated in publishing a paper entitled "Flax Facts," and consisting as before of five parts, each prepared by a separate institution. Unfortunately, the publication was not assigned to any series of the Federal Department but is *Minnesota Extension Special Bulletin* 128, *Montana Extension Bulletin* 107, *North Dakota Extension Circular* 90, and *South Dakota Extension Circular* 293. While these two publications appear to be instances of interstate coöperation, it is evident that the Federal agency was the coördinating influence which made possible the joint publication in this form.

Interstate coöperation.—An early instance of true interstate coöperation can be given under flax studies. More than twenty years ago, the Montana and North Dakota Agricultural Experiment Stations published together, under joint authorship, the results of their independent experiments on methods of flax production. The first publication appeared in 1913 as a circular in the series of the Montana Station (61—22) and a bulletin of the North Dakota Station (74—103). The second publication, in 1914, was a circular in both series (61—40; 75—1). These are very early examples of that type of coöperation in publication by which one typesetting and printing served two agencies.

Intra-institutional coöperation.—In some cases, different divisions of the experiment stations have coöperated in flax investigations, as for example, agronomy, plant pathology, chemistry, agricultural economics, and agricultural engineering. In the Federal Department, the Bureaus of Plant Industry and Agricultural Economics coöperated in determining the quantity and quality of oil from samples of different varieties and from different geographic sources. Still earlier, the Divisions of Cereal Crops and Drug Plant Investigations, in the Bureau of Plant Industry, had worked together in determining the influence of source and variety on the linseed oil obtained (90—655), published in 1918.

Protection from Disease

The coöperative Federal-State studies of flax diseases have been confined chiefly to the Minnesota and North Dakota Agricultural Experiment Stations. In Minnesota, the coöperation covered flax rust, as part of a general collaborative study of cereal rusts. The results of coöperative experiments in the control of flax rust were published by the State Station (56—36) in 1926. Two Federal Divisions, Cereal Crops and Diseases and Fiber-Plant Investigations, were involved, as shown by cover statement and footnote. Later coöperative studies of the immunity of flax varieties from attack by flax rust were published in a private journal (81). A still earlier Minnesota publication on wilt resistance of flax (56—20) represented interdivisional coöperation by plant pathologists and agronomists.

In North Dakota, the coöperation covered investigation of a physiological trouble called heat canker, a discussion of which was published (90—1120) in 1923, and the pasmo disease, reported on (41—32:25) three years later. Later stages of these and other researches involved some measure of coöperation with the Wisconsin Station.

7. TOBACCO AND OTHER DRUG PLANTS

TOBACCO IS AN IMPORTANT and widely distributed farm crop in the United States. Among the many other drug and medicinal plants grown, only the hop is of more than local importance. Both tobacco and other drug plants have been the subject of Federal investigation since the beginning of the present century, but by separate agencies.

OFFICIAL AGENCIES

In the Federal Department of Agriculture, studies of tobacco problems were begun in 1898 by the Division of Vegetable Physiology and Pathology, the Division of Soils, and the Division of Chemistry. They worked in a loose collaboration which was continued after they achieved bureau status in 1901, the former as a unit of the Bureau of Plant Industry. Tobacco investigations were continued by Plant Industry in a Plant Breeding Laboratory, which became the Cotton and Tobacco Breeding Laboratory in about 1905.

The Office of Tobacco Investigations was established in about 1907 and the name changed to its present one, Tobacco and Plant Nutrition, in 1912.

The Bureaus of Entomology and Agricultural Economics, also, have taken part in studies of their phases of tobacco production and protection. The diseases have been investigated by the former Office of Cotton, Truck, and Forage Crop Diseases and by the present Division which handles production problems.

The Office of Drug and Medicinal Plants, established in the Bureau of Plant Industry soon after its creation in 1901, has had entire charge of the work with these other drug plants. Its research has been mainly of a laboratory nature, with relatively little opportunity for coöperative relations.

In the State stations, tobacco is assigned to the division of agronomy or farm crops. The limited work done with drug plants is usually sponsored by the division of botany.

TOBACCO

Most of this section is concerned with tobacco, for reasons stated earlier. Both production and protection from fungus diseases and insects are involved.

Production

Tobacco is relatively very sensitive to soil constituents and conditions, so it was only natural that the Federal Division of Soils was drawn early into tobacco investigations. The Pennsylvania Station, publishing on tobacco experiments (80—30) in 1895, acknowledged assistance from the Division on soil problems. Beginning in 1898, as noted above, the Division of Vegetable Physiology and Pathology and the Division of Soils collaborated in a series of fermentation studies and cultural experiments with tobacco in Florida (98—60 and 62) and Connecticut. Fermentation studies and soil surveys were begun in Connecticut in July, 1899, and the relation of soils to fermentation investigated. Four reports (98—59, 60, 65, and 68) were issued in 1899, 1900, and 1901. There was minor coöperation with the Connecticut Station in several ways during the study. The Federal Bureau of Chemistry made the necessary analyses. Because of the interest excited, the Federal Office of Experiment Stations collaborated by preparing an abstract of

all the work done by the State experiment stations on tobacco (98—63).

In 1900, a remedy for some of the observed troubles was sought through growing the tobacco under artificial shade (129—20; 121—138), the Connecticut Station again coöperating. In 1901 the Bureau of Soils continued the work independently. In 1903, the Bureau of Plant Industry took up independent studies in the Connecticut Valley. The coöperative investigations mentioned above were discussed in the chapter on Agricultural Chemistry. Later, the Bureau of Soils worked with the Virginia Station in a study of tobacco improvement (129—46), published in 1907.

With the organizing of an Office of Tobacco Investigations in the Bureau of Plant Industry, a definite program of cultural studies with reference to quality was begun, to which protection from diseases was soon added. Most of the work was done independently of State agencies, however, for several years, as shown by some fifteen noncoöperative publications from 1907 to 1915. Coöperation on tobacco production was begun with the Virginia Station in 1906, the North Carolina Station in 1910, the Pennsylvania Station in 1912, and the Tennessee and West Virginia Stations in 1913, and in disease control with the Wisconsin Station in about 1914.

Some experiments were organized on a uniform basis in several States and the results published together by the Federal agency. For instance, fertilizer tests with flue-cured tobacco were conducted from 1912 to 1924 in coöperation with the North Carolina and Virginia Stations, the Georgia College of Agriculture, and the Georgia Coastal Plain Experiment Station (92—12). Studies of the magnesium and calcium requirements of tobacco (41—40:145) were in coöperation with North Carolina, Connecticut, Georgia, and Maryland Stations, and a study of the effects of chlorine (41—40:627) was coöperative with the Maryland and North Carolina Stations.

In Virginia, the Federal Office of Tobacco Investigations began independent fertilizer experiments on tobacco, at Appomatox, in 1904. The Virginia Station was enabled to begin collaboration with the Federal agency in 1906 by means of a special appropriation, continued thereafter. The major experiments were begun at Appomatox, with others at Chatham and two or three other points. An

extensive series of publications resulted, including progress reports (139—175 and 183) in 1908 and 1909, crop-rotation and fertilizer experiments with sun-cured (139—196) and bright (139—198) tobacco, and growing and curing of the former (139—197), all published in 1912, and experiments with dark tobacco (139—206) and a ten-year summary (139—205) put out in 1914.

The North Carolina Station, where coöperation began in 1910 on the Tobacco Branch Station (90—562), is sponsored jointly by the College of Agriculture and the State Department of Agriculture. Reports on tobacco culture in North Carolina (72—237) and on harvesting methods (72—238) were issued in 1917. The relation of potash to a magnesium deficiency causing chlorosis was published (41—23:27) in 1923, and the effects of chlorine, bromine, and fluorine (41—46:889) were studied in 1931. Research in other mineral nutrients, carried on in several States at the same time, was discussed above. Experiments on the culture of flue-cured tobacco were published in 1933 by the State Department.

Federal coöperation with the Pennsylvania Station was begun in 1912. A State law required coöperation also by the Tobacco Growers' Association. Results of experiments from 1912 to 1922 were published by the State (80—179). Further findings from 1922 to 1927 were similarly published (80—240) in 1929.

In Tennessee, in 1913, the State Station obtained a ten-year lease on a sixteen-acre experimental field at Clarksville and began coöperative experiments on tobacco with the Federal Division. The ten-year results of fertility experiments on dark tobacco, 1913—22, were made public (87—129) in 1924. In about 1932, the coöperative tobacco experiments in Tennessee were relocated on a Tobacco Substation at Greenville.

In West Virginia, also in 1913, Federal-State coöperation in tobacco production was begun, with a special appropriation from the West Virginia Legislature and additional funds from the Federal Division. A publication on White Burley was issued (144—152) in 1916. Varietal experiments were begun coöperatively at Lakin in 1922, with results published (144—216) in 1928.

Federal Division coöperation with the Maryland Station was begun in about 1919 on a special tobacco experiment station. The principal studies covered the effect of fertilizers and crop rotations

on tobacco yields and quality. The results of the cropping tests were published (48—275; 41—30:1095) in 1925. Results of eleven years of study of nitrogen nutrition (92—414), from 1919 to 1929, appeared in 1934, with acknowledgment of assistance from the Bureau of Chemistry and Soils.

In Georgia, experiments have been conducted in coöperation by the Federal tobacco agency, the State College of Agriculture, and the then independent Coastal Plain Experiment Station, both of which are now a part of the State University system. Some of the activities in Georgia have been listed above in the discussion of experiments carried on jointly in several States.

Federal coöperation with the Wisconsin Station was concerned chiefly with tobacco diseases, discussed below. In recent years, however, the relation of air conditions to curing (147—110) has been studied, as well as some fermentation phenomena (41—49:137).

Protection

The diseases of tobacco have received considerable coöperative attention, but the work on tobacco insects largely has been independent.

Fungus and bacterial diseases.—In Maryland, studies of tobacco mosaic were conducted on the Tobacco Experiment Station maintained in coöperation with the State Station. Its effects on yield and quality, with suggestions for control, were published by the State (48—302) in 1928. Further data appeared (41—38:257) in 1929.

In Pennsylvania, the previously noted Federal coöperation with the State Station on tobacco production was followed by studies of resistance to black root rot (80—193), issued in 1925. Later coöperation covered seedbed management in relation to wildfire control (80—274), published in 1932.

At the Massachusetts Station, a study of wildfire made in 1922 in Federal-State coöperation (49—213) was in coöperation also with the Connecticut Tobacco Experiment Station, which published the same information as its bulletin No. 2. An investigation of brown rot conducted in coöperation with the Wisconsin Station some ten years ago involved the Connecticut and Massachusetts Stations also (90—1410).

In North Carolina the coöperative experiments established in 1910 gave much attention in the early years to the problem of wilt. Experiments in its control were conducted from 1910 to 1914, inclusive (90—562).

At the Wisconsin Station, Federal-State experiments on tobacco diseases were begun in about 1914. Additional host plants for *Thielavia basicola*, causing root rot, were reported (41—7:289) in 1916, and the influence of soil environment on it (41—17:41) in 1919, under joint authorship. Breeding for resistance to the root rot was conducted in coöperation with the State Station Division of Horticulture and reported (92—175) in 1930.

A study of fusarium wilt appeared (41—20:515) in 1921. A general discussion of tobacco diseases and their control was presented (90—1256) in 1924. Research on a bacterial leafspot was published (41—23:481) in 1923, and the toxin produced by it, in relation to host range, was studied recently (41—48:411). In 1922, the Wisconsin State Department of Agriculture and the College of Agriculture began a survey and campaign for the control of tobacco wildfire (146—348). At the same time the Wisconsin Station and the Federal Division began coöperative experiments on the disease (147—62). From 1923 to 1928 these latter agencies collaborated also in a study of the overwintering of the virus of tobacco mosaic (147—95). Some circumstances of the aphid transmission of cucumber mosaic to tobacco also were studied recently (41—47:689). An investigation, jointly authored, of brown rot (90—1410), some ten years ago, involved the Connecticut and Massachusetts Stations also.

Insects.—The only discovered coöperation by the Bureau of Entomology with State stations in the control of tobacco insects occurred in Tennessee. Studies of methods of control conducted from 1907 to 1909 were reported (111—123), as well as research in lead arsenate as a control for tobacco hornworms, conducted (111—173) in 1910—11.

OTHER DRUG PLANTS

Drug-plant investigations in the Bureau of Plant Industry date from about 1904. Extensive studies of production, utilization, and protection have been made. Much of the research has been made in

the laboratory and therefore the opportunity for coöperation has been relatively limited.

Production

In a Federal study of the source of the drug plant *Dioscorea*, and related plants, the receipt of information and material from many State stations, agricultural colleges, and State universities was acknowledged (121—189) in 1910. The commercial possibilities of Japanese mint as a source of menthol were investigated and published (92—378) with coöperation from the Alabama and Virginia Polytechnic Institutes and the Schools of Pharmacy in the State Universities of Florida, Oklahoma, and North Carolina.

During the past several years, tests of the production of safflower for oil purposes have been conducted by the Federal Division on the State stations and substations in Colorado, Illinois, Indiana, Kansas, Minnesota, Montana, Nebraska, North Dakota, South Dakota, Texas, and Wyoming, as well as on field stations of other Plant Industry Divisions (97—64 and 129). In the same period, studies of the production of roses for perfume and of the plant producing santonin have been conducted coöperatively in Oregon.

Protection

In about 1911, the control of ginseng diseases was studied and jointly reported on by the Federal Office of Cotton and Truck Crop Diseases and the Department of Plant Pathology of the Cornell College of Agriculture (121—250).

In 1910, a severe outbreak of the mite or "red spider" of hops in California brought an urgent request for the assistance of the Federal Bureau of Entomology. The study was made (109—117) in 1911—12, with office facilities provided by the State insectary and suggestions furnished by the State station. Later studies on quassia as a contact insecticide for the hop aphid (90—165) acknowledged suggestions from the University of California. In 1930, after the outbreak of downy mildew of the hop in British Columbia, the California State Department of Agriculture published an account of the disease (12—19:513) prepared by a Federal worker. The presence of arsenic in hops was studied and authored jointly by Plant Industry and Chemistry (90—568) in 1917.

The publications listed in the Literature Cited at the end of this chapter which have been cited in these sections on Oil Crops and Tobacco and Other Drug Plants are Nos. 12, 41, 48, 49, 56, 61, 72, 74, 75, 80, 81, 86, 87, 90, 91, 92, 94, 97, 98, 109, 111, 121, 129, 139, 144, 146, and 147.

8. SUGAR CROPS

THE PRINCIPAL PLANTS producing sugar and sirup are sugar beet, sugar cane, sorgo or saccharine sorghum, and sugar maple.

The early studies on the three crops first named were chiefly chemical in nature and have been discussed already in chapter 4, devoted to Agricultural Chemistry. The most recent crop experiments, primarily agronomic or protective, are presented herewith.

OFFICIAL AGENCIES

The Federal Division (later the Bureau) of Chemistry was the first agency to coöperate with the States in sugar-plant investigations. It was followed by the Office of Sugar Plant Investigations of the Bureau of Plant Industry and the Division of Truck Crop Insects of the Bureau of Entomology, as well as by the Office of Farm Management, later a part of the Bureau of Agricultural Economics. Some early work on sugar-beet diseases was done by the former Office of Forage and Truck Crop Disease Investigations. The Division of Soil Fertility, sometimes in Chemistry and Soils and sometimes in Plant Industry, takes part in fertilizer tests, and the Division of Farm Machinery of the Bureau of Agricultural Engineering coöperates on mechanical problems. Other Federal agencies making minor contributions will be named at appropriate points in the discussion which follows.

The State agencies comprise the station divisions of agronomy and horticulture on the production side and the divisions of entomology and plant pathology on the protection side. Divisions of chemistry and agricultural industry assist, as does the extension service.

SUGAR BEET

The coöperative official investigations of the sugar beet may be divided into early chemical and economic studies and later experiments in production, improvement, and protection.

Chemical and Economic Studies

Official Federal investigation of sugar beet began in 1888, when the Division of Chemistry took up the problem. The State stations were asked to collaborate in growing seed furnished by the Department, which in turn made the analyses of the resulting crops and summarized results of both coöperative and independent studies. The investigation was continued through 1893 and resulted in five successive publications (105—3, 30, 33, 36, and 39) between 1890 and 1893. The work was reëstablished in 1897 on a similar coöperative basis and the results for that year published (105—56). Plant Industry collaborated in obtaining the seed stocks.

In 1900, the Division of Chemistry expanded the project to a comprehensive study of the influence of environment, chiefly climate and soil, upon the composition and yield of the sugar beet. Identical lots of selected seed were furnished to State stations chosen because of their climatic and soil conditions. Samples of beets and soil were analyzed by the Division and sometimes by the States also. The Weather Bureau collaborated in furnishing the climatic data. The length of the day at each station was computed by the Naval Observatory and the altitude and latitude of each station were contributed by the Coast and Geodetic Survey, then of the Treasury Department. In 1902, the Bureau of Chemistry was specifically authorized by Congress to coöperate with the Weather Bureau and the State stations in these studies. The experiments were continued during the five years from 1900 to 1904 and the results published annually (105—64, 74, 78, 95, and 96), the last containing a five-year summary.

The States coöperating in some or all of the five years were California, Colorado, Indiana, Iowa, Kentucky, Michigan, New Mexico, New York (both stations), North Carolina, Oregon, Utah, Virginia, Wisconsin, and Wyoming. Coöperation was indicated with unusual prominence and frequency in this series of bulletins, on cover and title page, in the Letter of Transmittal, the Table of Contents, and the introductory text, with the coöperation of each State again plainly shown where its data were presented. This series is to be regarded as an early and gratifying example of prominent and precise display of coöperative relations.

In the meantime, a commercial and agricultural study of sugar-beet production in the United States was being made by a special agent appointed by and responsible to the Secretary of Agriculture. Annual reports were prepared for the years 1897 to 1909, excluding 1903. They well illustrate the changing functions of the developing bureaus of the Department. The first four, for 1897-1900, were joint products of the special agent and the Division of Chemistry, with each part under separate authorship (127; 98-69). Those for the years 1901 to 1909, excluding 1903, were similar joint products of the special agent and the Bureau of Plant Industry (98-72, 74, 80, 82, 84, 86, 90, and 92), the latter Bureau at first being limited to discussions of seeds and diseases, but including fertilizers from 1904 and all cultural phases from 1906 onward. As early as 1902, the Congress had authorized the Bureau of Plant Industry to continue inquiries on the progress of the beet-sugar and sorghum-sugar industries. From 1906 onward, the reports were transmitted to the Secretary by the Bureau rather than by the special agent.

Production Studies

The early studies of the Federal Office of Sugar-Plant Investigations on sugar-beet production and on the cause and control of the curly-top disease were conducted independently of other Federal or State agencies. From 1914 to 1918, however, there was coöperation with the Office of Farm Management in studies of farm practice in growing sugar beet in the different eastern and western areas, published mostly under common authorship (90-693, 726, 735, 748, 760, and 963) in 1918 and 1921.

Beginning in 1931, the Division of Sugar Plant Investigations and the Agricultural Engineering Division of Mechanical Equipment made extensive tests of mechanical blocking and cross cultivation of sugar beets, in coöperation with commercial agencies and with the State Stations of California, Colorado, and Minnesota, and issued the results (93-316) in 1934 under joint authorship.

In the discussions which follow, it is understood that the Federal agency is the Division of Sugar-Plant Investigations unless otherwise stated.

Eastern area.—Experiments conducted from Michigan westward to the foothills of the Rockies are considered to be in the East-

ern area. Most of them have been established or have become coöperative within the last ten years.

At the Michigan Station, general agronomic and breeding investigations (Federal-State) have been conducted coöperatively for several years (97—64 and 129). At the Minnesota Station the co-operative experiments (Federal-State) were established in 1931 and cover production, breeding, and protection (97—129). With assistance from the National Research Council, special coöperative studies have been made there recently on the technic of sampling sugar beet (41—44:633) and on size and shape of plots in relation to field experiments (41—44:649 and 47:591), and published in 1932 and 1933.

In Colorado, independent Federal sugar-beet experiments have been conducted for many years at Rocky Ford. In about 1930, minor experiments previously carried on coöperatively at the State Station were expanded to include general agronomic and breeding operations and made fully coöperative under formal agreement. The Laramie County Hospital assisted with land for experimental plots. Studies on conditions influencing self-fertilization were published (41—48:323) in 1934. Fertilizer studies were conducted coöperatively in Colorado by the Division of Soil Fertility of the Bureau of Chemistry and Soils and the Division of Sugar Plant Investigations from 1921 to 1928 and jointly authored (93—319) in 1934. In Montana, the Station coöperated with the Plant Industry Division of Western Irrigation Agriculture at the Huntley Substation on sugar-beet production and published under joint authorship (60—215) in 1928.

In New Mexico, the Federal Division began formal coöperation with the State Station in 1918 on general production studies (69—162). In 1922, the emphasis was placed on seed production, the results from 1922 to 1927 on production from beets overwintered in the field being published (93—20). These and later results to the end of 1929 were jointly authored (93—153) in 1931 and still later data on methods of producing seed were similarly issued (69—207) in 1933. General agronomic studies were added again as the work progressed (97—64 and 129).

Western area.—Most of the work done in the far western States is concerned with the curly-top disease and most of the agronomic

activities are directed toward its control. The production studies in Utah are centered at Salt Lake City, independent of the State Station. In Idaho they are conducted at Twin Falls, in connection with curly-top studies, independent of the State but in nominal coöperation with the Federal Bureau of Entomology.

In California, the Office of Sugar Plant Investigations and Office of Farm Management coöperated in a study of farm practices in growing sugar beet (90—760), as noted previously. The California Station took part also in the widespread Federal-State study of mechanical blocking and cross cultivation (93—316), published in 1934. A Station study of the time of seeding sugar beet in central California (8—526) acknowledged assistance from the Federal Division of Sugar Plant Investigations and the Station Division of Entomology.

Protection Studies

Almost all the coöperative activities in sugar-beet protection are concerned with the curly-top disease. Only two others have been noted. In 1915, the Federal Division of Forage and Truck Crop Diseases published a discussion of seedling diseases of sugar beets and their relation to root rot and crown rot (41—4:135), in coöperation with the Wisconsin Station. In 1929, the California State Department of Agriculture published (12—18:267) notes on the sugar-beet army worm in California, prepared by the Federal entomologist in charge of the independent field station in that State. In Utah, Federal coöperation with the State Station in recent years, but now discontinued, covered beet diseases, especially root rot (97—64).

Coöperative investigations of the curly-top disease and the leaf hoppers associated with it have been conducted in Utah and Idaho, but more extensively in California.

Idaho and Utah.—On August 1, 1925, the Federal Bureau of Entomology, through its Division of Truck Crop Insects, entered into formal coöperation with the corresponding divisions of the Idaho and Utah Stations in a study of the beet leaf hopper and its relation to the curly-top disease. Different phases of the problem have been reported upon by the Utah Station (137—65; 136—212 and 234) from 1927 to 1932. The Idaho Station published a comprehensive report of the coöperative results (34—182) in 1932.

The Idaho studies were made at Twin Falls, where the Bureau of Entomology has its western headquarters for leaf-hopper research. Later, the Montana and California Stations entered the coöperation.

The Plant Industry Division of Sugar Plant Investigations also conducted extensive experiments on the curly-top disease at its Twin Falls Field Station, on control methods, wild host plants, and the effects of agronomic practices on the disease. There was nominal coöperation with the Bureau of Entomology, in whose building they had quarters, but none with the State Station. In 1931, they coöperated with the Division of Soil Fertility, then in the Bureau of Chemistry and Soils, on the effects of seeding time and fertilizer mixtures on a variety resistant to curly top (93—273). For a brief time the Plant Industry Division coöperated also with the Utah Station on the curly-top disease (97—64), but most of its investigation of this disease in Utah has been conducted at an independent Federal field station at Salt Lake City (97—64 and 129).

California.—The study of the curly-top disease of the sugar beet in California has involved the Federal Divisions of Truck Crop Insects, Sugar Plant Investigations, and Horticultural Crops and Diseases, and the Station Divisions of Entomology, Botany, and Truck Crops.

The Federal Divisions of Truck Crop Insects and Sugar Plant Investigations have been working in California for about twenty years, at first entirely independently of the Station. In 1917, the two Divisions began coöperation on curly-top studies and published on obtaining nonvirulent leaf hoppers (41—14:393), the curly-top disease (41—28:297), and resistance to the disease (94—388), from 1918 to 1926, the first two being jointly authored. The coöperation was discontinued in 1925. The laboratories and field facilities of the Citrus Experiment Station at Riverside were used for much of the study.

In 1926, the California Station, through its Division of Entomology, began coöperation with the Division of Truck Crop Insects of the Federal Bureau of Entomology, as part of the previously mentioned Federal-State attack on the curly-top disease of the sugar beet. The first study, on host plants of curly top (31—3:339), was coöperative with the Federal Division of Sugar Plant

Investigations also. A determination of the identity of tomato yellows with the curly top of beets was made (31—3:251) in 1927 with the coöperation of the Federal Division of Horticultural Crops and Diseases and the California Division of Truck Crops. Critical coöperative histological and microchemical laboratory studies on the hopper and the curly top were published in *Phytopathology* from 1928 to 1930.

Later coöperative studies by the two entomological agencies include the methods of curly-top transmission (31—6:253), transmission of carrot, parsley, and parsnip yellows (31—7:163), some properties of the curly-top virus (31—8:1), weed-host range and overwintering of the virus (31—8:263), ornamental flowering plants naturally infected with curly-top and aster-yellows viruses (31—8:233), and a series of three papers on the aster-yellows virus (31—8:305, 329, 339), all between 1931 and 1934. A summary of field observations made on the beet leaf hopper from 1918 to 1932 was published (31—7:281) in 1933.

In 1929, the Federal Division of Truck Crop Insects established at University Farm, Davis, California, a branch laboratory of its field laboratory at Twin Falls, Idaho. By informal agreement, the California Station provides office and laboratory space for the Federal agents, whose principal activity is to maintain inspection of the beet-producing areas, determine conditions, and forecast outbreaks of the leaf hopper. A similar branch laboratory was set up at the same time at the Citrus Experiment Station, Riverside, to study host plants and the natural breeding areas of the hopper. By informal agreement with the Office of Sugar Plant Investigations, the laboratory is quartered in the Girls' High School building occupied by the Federal agency.

SUGAR CANE

In 1830, the Congress directed the Secretary of the Treasury to prepare a manual on the culture of sugar cane and the refining of sugar, which was done in 1833. In 1884 the Federal Division of Chemistry began experiments in the chemical control of the processes of sugar manufacture, in coöperation with commercial plantations in Louisiana. At the same time, experiments were begun at the Kenner Sugar Experiment Station, in coöperation with the

Louisiana Station. Published reports contained both coöperative and independent data (105—22 and 23). In 1902, under authorization from Congress, the Bureau of Chemistry began an apparently independent study of sirup production from sugar cane in Georgia. These early studies have been discussed in chapter 4, on Agricultural Chemistry. More than twenty years later, this Bureau collaborated in further studies of sugar-cane sirup manufacture, the resulting publication (90—1370) containing chapters by the Bureaus of Chemistry and Plant Industry and the Louisiana Station.

Production

Agronomic studies in sugar-cane improvement and culture were begun by the Office of Sugar Plant Investigations as early as 1916 (90—486). Most of these experiments have been conducted, however, on commercial sugar plantations or on independent Federal sugar stations. One of the latter has been maintained at Canal Point, Florida, and another at Houma, Louisiana.

In about 1927, a conference was held by the Federal Office, the Louisiana Station, and the American Sugar Cane League, at which it was agreed that the two official agencies would exchange data obtained independently on their respective sugar stations. The Louisiana Station, in reporting thereafter on varietal and fertilizer tests on its stations and test fields (46—199, 202, 203, and 211) included data from the Federal sugar station in that State and acknowledged its coöperation from 1928 onward. In about 1934, the Federal experiments at the sugar stations named above, in Florida and Louisiana, were made coöperative with the respective State stations (97—233). Coöperative studies by the Bureaus of Plant Industry and Chemistry and Soils from 1930 to 1932 on storage of mill cane were published (92—449) in 1934.

Protection

There has been minor coöperation in studies in the control of sugar-cane insects. In 1910, the Federal Bureau of Entomology established a Sugar-Cane Insect laboratory at New Orleans in connection with the State Sugar Experiment Station. A full report on the coöperative studies of the sugar-cane moth-borer was published (90—746) in 1919. In 1923, the Louisiana Station published (46—

185) an investigation of control of the sugar-cane mealy bug, conducted jointly with the Bureau of Entomology. In 1927, it published (46—198) a similar coöperative study of the control of the sugar-cane moth-borer by the use of trap corn. In 1927 the Bureau of Entomology coöperated with the Division of Sugar Plants in experiments on the application of sodium fluosilicate by airplane, to control the moth-borer (93—45). A Federal report (92—41) on this insect in 1928 makes no mention of coöperation, but cites some experiments conducted on the Louisiana Sugar Station.

SORGO OR SWEET SORGHUM

The minor coöperation developed by the Federal Division of Chemistry in its early investigations of sorgo as a sugar plant has been described in chapter 4, on Agricultural Chemistry (p. 293, above). The studies of sorgos as forage plants, made by the Office of Forage Crop Investigations, were presented under the preceding section on Forage Crops, as were also the studies of sorghum diseases conducted by the Office of Cereal Crops and Diseases. All of these are applicable to the sorgo as a sirup plant.

The Office of Sugar Plant Investigations conducted studies of this group of sorghums as sirup producers for several years, but there was little or no coöperation with other official agencies. The work has now been transferred to the Division handling the sorgos as farm crops.

Very recently, the Agricultural and Agricultural Industries Divisions of the Tennessee Valley Authority have been coöperating informally with the Extension Divisions of the Tennessee and Georgia Colleges of Agriculture in community production of pure seed of adapted varieties for community sirup production.

SUGAR MAPLE

Very little coöperation has developed in studies of the sugar maple as a source of sirup and sugar. Recently, in connection with its tariff problems, the United States Tariff Commission coöperated with the Vermont Station on an economic study of maple-sugar manufacture, published by the Station (138—285, 286, and 292) in 1928 and 1929.

The publications listed in the Literature Cited at the end of this

chapter which have been cited in this section on Sugar Crops are Nos. 8, 12, 31, 34, 41, 46, 60, 69, 90, 92, 93, 94, 97, 98, 105, 127, 136, 137, and 138.

9. VEGETABLE AND TRUCK CROPS

MANY AND DIVERSE CROPS are included in the two groups, the so-called vegetable and truck crops. Among them are such root and tuber crops as potato, sweet potato, carrot, parsnip, radish, and turnip; such leaf and stem or salad crops as cabbage, cauliflower, celery, globe artichoke, lettuce, and onion; such fruit-producing truck crops as tomato, eggplant, and peppers; such legumes as bean, Lima bean, and garden pea; and such members of the cucurbit or melon family as cucumber, cantaloupe, pumpkin, squash, and watermelon. Not all of these have been the subject of coöperative action by official agencies.

OFFICIAL AGENCIES

In the Federal Department of Agriculture the principal Bureaus concerned with vegetable production and protection have been Plant Industry and Entomology. In the former, the Office of Horticulture and the Office of Cotton, Truck Crop, and Forage Crop Diseases have been responsible for production and protection studies, respectively. In 1928, both were merged into the Office of Horticultural Crops and Diseases, since renamed the Division of Fruit and Vegetable Crops and Diseases. In Entomology the Division of Truck Crop Insects has been the investigating agency. The Office or Division of Soil Fertility Investigations, which has shuttled back and forth between the Bureaus of Plant Industry and Chemistry and Soils, has conducted coöperative investigations of fertilizers.

The State agencies have been the station divisions of horticulture, entomology and plant pathology, and in some cases the State departments of agriculture. County commissioners and an occasional city also have taken part. A few other agencies, both Federal and State, are mentioned at appropriate points in the text.

GENERAL PRODUCTION

Almost no Federal-State coöperation has developed in the production of vegetable crops. In some States there is interinstitu-

tional coöperation in safeguarding the purity and viability of vegetable-seed stocks, as in Connecticut where the State Station and State Department of Agriculture work together (20—283). Some recent Federal-State coöperation has occurred in connection with the marketing of vegetables.

The Florida Station with the aid of the Federal-State Crop Reporting Service made a study of interstate and foreign competition with Florida truck crops (24—224) in the shipping years 1924—29. A New Jersey Station study of fruit and vegetable farming in New Jersey (68—555), during 1926—31, was coöperative with the Federal Division of Farm Management in the first year. A later study of New York city market prices for certain New Jersey vegetables from 1910 to 1933 was made by the Station (68—575), with financial assistance from the Federal Civil Works Administration. In New York, the Cornell Station Division of Agricultural Economics, in 1934, published studies of marketing (70—585) and consumption (70—586) of perishable farm products in Albany, with assistance from the Bureau of Markets of the New York State Department of Agriculture and Markets. The Rhode Island Station published (82—220) in 1929 on preferences and practices in buying vegetables in Providence, acknowledging helpful suggestions from the Federal Department of Agriculture.

In the nation-wide Federal-State coöperation on vitamin research a few studies of vegetables are under way. In the meantime, the Georgia Station has published a study of the vitamin content of turnip greens, collards, cantaloupes, and peaches (26—167) in coöperation with the Department of Home Economics in the Georgia State College. In Iowa, coöperation in a study of the vitamin B content of vegetables (40—120) was between the Station Sections of Home Economics and Vegetable Crops.

Varietal Descriptions and Standards

Investigations to determine the varietal identity of the more widely grown vegetables and to describe varietal characteristics have been conducted independently by the Federal Division of Fruit and Vegetable Crops and Diseases for many years. Only since about 1928, however, have these studies been carried on jointly with the State stations.

The varietal studies of carrots and beets have been made in co-operation with the California and Louisiana Stations, the Texas Station at Substation No. 15 at Weslaco and Substation No. 19 at Winter Haven, and the Virginia Station at its Truck Experiment Station. Similar coöperative experiments resulting in published descriptions of cabbage varieties (97—169) were conducted in coöperation with the California, Pennsylvania, South Carolina, Texas, and Virginia Stations, the latter on the Truck Experiment Station. Descriptions of the types of the principal American varieties of garden peas (97—170) resulted from coöperation with the Peninsular Branch Station of the Wisconsin Station.

Similar studies of the varieties of spinach have been made in coöperation with the California, New York (Cornell), and Texas Stations, the latter on its Substation No. 19 at Winter Haven. Published descriptions of tomato varieties (97—160) were based on coöperative studies at the California, Indiana, Michigan, New York (Cornell), and Texas Stations, in the latter case at Substation No. 11 at Nacodoches and Substation No. 15 at Weslaco. Very recently similar studies of onion varieties have been begun in co-operation with Texas Substation No. 19 at Winter Haven.

GENERAL PROTECTION

Diseases of fruits and vegetables which develop during storage or transportation often are very destructive and often cause severe losses to shippers and purchasers. Since 1917, what is now the Plant Industry Division of Fruit and Vegetable Crops and Diseases and the Agricultural Economics Division of Fruits and Vegetables have coöperated extensively on this problem, especially at Chicago and New York, the major terminal markets. In Chicago, a co-operative Research Laboratory of Market and Transit Diseases of Vegetables and Fruits was established in the Department of Botany of the University of Chicago. Among the resulting studies were botrytis rot of globe artichoke (41—29:85), *Sclerotinia* species causing decay of vegetables (41—31:597), fusariums causing onion bulb rot (41—33:929), ammonia injury to onions and fruits (41—37:339), and tomato nailhead (41—38:131), the latter co-operative also with the Florida Station, and all appearing between 1924 and 1929.

Recently these agencies have been publishing a series of handbooks on market diseases, prepared jointly by the University of Chicago and the Federal Bureau of Plant Industry. The first covered market diseases of the potato (97-98) and the second the market diseases of tomato, pepper, and eggplant (97-121), both appearing in 1932.

In 1928, the Federal Division of Truck Crop Insects entered into an informal agreement with the California Station Division of Entomology for a coöperative investigation of the vegetable weevil, at the Deciduous Fruit Experiment Station at San Jose. The State Department of Agriculture (12-17:482) also coöperated in the scouting to determine the distribution and spread of the insect. The project was directed by a committee of three, one from each of the official agencies involved. The California Experiment Station published an extensive discussion of the problem (8-546) in 1932.

BEAN AND PEA

The Federal Division of Fruit and Vegetable Crops and Diseases has engaged in coöperative experiments, at a few points, on beans and bean diseases. For a few years bean breeding and the control of bean diseases were studied at the Greeley Potato Station in Colorado, under a Federal-State-county coöperation which is explained fully in the subsection on potato investigations. Similar work was done at the Twin Falls Sugar Plant Field Station in Idaho, where some informal coöperation was had with the Division of Sugar Plant Investigations and the Bureau of Entomology, in whose building the laboratory was established (97-129). These experiments in Colorado and Idaho have been discontinued. A bacterial blight of beans was studied in coöperation with the Wisconsin Station and published (92-186) in 1930.

Studies of the life history and control of the Mexican bean beetle were made by the Federal Division of Truck Crop Insect Investigations in coöperation with several State stations. The Alabama results (1-221), obtained in 1921-22, also acknowledged assistance from the city of Birmingham. South Carolina results, obtained in 1924-26, were published (84-236) in 1927. New Mexico data (69-199) appeared in 1932. The Federal Division itself compiled extensive data on the life history and control of this beetle, ob-

tained in 1923-30, and published (97—376) in 1933, with acknowledgement of assistance from the Forest Service and the Weather Bureau but without mention of any coöperation with State stations.

In 1918, the Federal Division of Stored Product Insects established a noncoöperative Bean Weevil Laboratory in California. Some of the resulting publications (41—28:347) referred to assistance from the State Department of Agriculture. In January, 1928, the laboratory was moved to Modesto in the San Joaquin Valley. Here the work was conducted in informal coöperation with the Agricultural Commissioners of Merced, Stanislaus, and San Joaquin counties and the State Department of Agriculture. In 1930, the Division of Truck Crop Insects and the Agricultural Commissioner of Ventura County coöperated in a study of the Lima-bean pod borer which was published by the State Department of Agriculture (12—19:409).

The description of garden-pea varieties already has been noted (97—170). Pea-breeding experiments were begun recently by the Federal Division at the Davis Experiment Farm of the California Station (97—233). Temporary studies of the inheritance of the "rogue" type in peas were conducted by the former Office of Cotton, Truck, and Forage Crop Diseases and the Department of Botany of the University of Michigan (41—24:815). A survey of pea diseases in Wisconsin was made in 1924 by the Federal Division (147—64) and the Wisconsin Station. Similar coöperation on a study of pea root rot was published (41—30) at the same time.

CUCURBITS OR MELONS

The cucurbit or melon group includes cucumber, cantaloupe, pumpkin, squash, and watermelon. Little coöperation has been developed except in the protection of cucumber from disease.

In 1930 the horticulture section of the Michigan Station made a study of cantaloupe production in Michigan (52—193), with assistance from the Federal Market News Service in Chicago and from the school authorities of Benton Harbor who permitted the use of the chemical laboratory of its high school.

In about 1917 the Office of Cotton and Truck Crop Disease Investigations began coöperation with the Indiana and Wisconsin Stations in a study of cucumber diseases. The Indiana coöperation

was temporary, covering only a study of *Stemphylium* leaf spot (41—13:295). The coöperative relations in Wisconsin have been maintained to the present time. Coöperative publications have covered research in the angular leaf spot (41—15:201), and anthracnose of cucurbits (90—727), and a later series on the mosaic disease, including cucumber mosaic (41—31) and its control by control of host plants (90—1461).

A recent paper on factors of aphid transmission of the cucumber mosaic to tobacco was in coöperation with the Plant Industry Division of Tobacco Investigations. In 1923, the Wisconsin Station and the Federal Bureau of Entomology authored jointly a study of control of cucumber beetles by nicotine dust (146—355).

LEAF AND STEM CROPS

The principal vegetable crops grown for their leaves or stems are asparagus, cabbage and its relatives, celery, lettuce, and onion. There has been almost no coöperation in investigations of the production of these crops. In studies of marketing problems and of protection from fungus diseases and insects, however, a considerable coöperation has developed.

Marketing

Coöperation in the marketing of vegetable crops was discussed in the chapter on Agricultural Economics, so that only a brief summary need be given here. As early as 1917 a study of handling Florida lettuce and celery (90—601) was published jointly by the Federal Bureaus of Plant Industry and Markets. In marketing head lettuce, the Colorado Station (19—283) in 1923 acknowledged data on car-lot shipments furnished by the Colorado Division of Marketing and the Federal Division of Fruits and Vegetables. In California a study of asparagus crops and prices (8—487) was a product of the Federal-State Crop Reporting Service and Extension Service, the Federal Division of Fruits and Vegetables, and the Bureau of Foreign and Domestic Commerce of the U. S. Department of Commerce.

A recent California study of marketing the globe artichoke (8—524), in 1932, was based on coöperation of the Station Division of Agricultural Economics, the Federal-State Market News Service,

the agricultural commissioners of Monterey and San Luis Obispo Counties, and the farm advisers of Marin, Monterey, and Santa Cruz Counties.

Protection

In Florida the State station and the Federal Division of Vegetable and Forage Crop Diseases jointly carried through a study of the diseases of lettuce and similar crops (24—195) in 1928. Celery protection in Florida was the object of continuing Federal-State coöperation. In 1924, the two plant-disease units discussed celery diseases (24—173) under joint authorship. Later, the Federal Bureau of Entomology entered into coöperation with the Florida Station and the State Plant Board in a study of celery insects (24—250), including the leaf tier (24—251), both jointly authored in 1932.

The Federal Plant Industry Division of Cotton, Truck, and Forage Crop Diseases has conducted coöperative investigations of vegetable diseases, chiefly those of cabbage and onion, with the Wisconsin Station since about 1918. Much attention has been paid to breeding for resistance. Among the diseases studied coöperatively have been cabbage blackleg (90—1029), the fusarium disease and resistance to it (147—48; 41—30, 40, and 47), and the inheritance of this resistance in Brussels sprouts and kohlrabi (41—46:1015). Other studies include the clubroot of crucifers (92—181), head rot and bottom rot of cabbage (41—45:461), and soil treatment in relation to clubroot of cabbage (41—48:749), published in 1930 to 1934. A long-time coöperative study has been made of cabbage yellows (41—35 and 41) and resistance to it (41—37 and 46), including uniformity of strains of the causal organisms (41—48:401). Several of these papers were in joint authorship.

The extensive coöperative research in onion diseases covered the relation of soil temperature and other factors to onion-smut infection (41—22:235), onion-smudge resistance (41—24:1019), bulb rot (41—28), onion pigmentation (41—29 and 42), onion toxicity (41—30), neck rot (41—30 and 33), onion smut (41—32), and purple blotch (41—38), all published between 1922 and 1929.

A single study, made by the Federal Division, of a ring spot of crucifers in the peninsular counties of California used the labora-

tory and greenhouse facilities of the California Station (41—33:97).

TOMATO AND PEPPER

These fleshy-fruited vegetables have been the subject of very little official coöperation in production activities but of somewhat more concern in marketing and in protection from disease.

Production and Marketing

In California, the Station Divisions of Genetics and Truck Crops coöperated from 1922 to 1925 in the improvement of the tomato by selection (31—2), in which they acknowledged assistance from the U. S. Department of Agriculture. In Indiana, the Station Division of Horticulture investigated the buying of tomatoes on grades (37—328) in 1927—28, and tomato color as related to quality in the canning industry later (37—350), acknowledging the coöperative assistance of the Federal Division of Fruits and Vegetables. In New Hampshire, studies of the effect of phosphorus on yield and time of maturity of tomato (67—28) included some data from the Federal Office of Horticulture in 1918. In New Jersey, the Station and the Federal Division of Farm Management coöperated in an extensive economic study of the tomato-canning industry (68—353) published in 1921. An Ohio Station study of marketing cannerly tomatoes on grades (76—504), acknowledged the receipt of detailed information from the Ohio Division of Markets and Federal Division of Fruits and Vegetables.

Protection

In 1922, the Federal Division of Cotton, Truck Crop, and Forage Diseases entered into informal coöperation with the California Station at its Citrus Experiment Station, Riverside, in a study of the control of western tomato diseases. Investigations have been conducted continuously at that point ever since, but some phases of the project have been developed at other points at different times, as noted below. The study is concerned chiefly with the environmental factors of infection with tomato yellows or tomato blight.

While the work was located at the Rubidoux Laboratory, the Station provided land and also office, laboratory, and greenhouse

space, the Federal agency supplying apparatus for temperature and humidity control. Since the removal of the Citrus Experiment Station to a new location, greenhouse space has been lacking, and for this reason a portion of the project has been transferred to the Division of Plant Pathology at the State Station at Berkeley.

The pathologic studies directed by the Federal agency and the breeding studies directed by the State agency were completely correlated. Numerous coöperative publications resulted, beginning in 1924 with a study of varietal susceptibility to infection by fusarium wilt. The published results of the study of yellows included ecological aspects, improvement by selection (31—2:26), a study of resistance (31—2:47), experiments in control (92—189), effect of shading on the rate of development, and resistance of varieties and new dwarf races of tomato to the western yellow blight or curly top (31—6:29). The work conducted at Berkeley in coöperation with the Station Division of Truck Crops included a study of changes in the composition of the tomato plant accompanying different stages of yellows. A few of the shading tests were made at the Federal Cotton Station at Shafter.

In about 1927, the Federal Division of Horticultural Crops and Diseases began independent studies of verticillium wilt of tomato at San Jose. Two years later the State Station purchased the property now known as the Deciduous Fruit Experiment Station at that point. Since that time the studies on this wilt have been conducted on the State substation in coöperation with the Station Division of Plant Pathology.

In 1926, the Florida Station and the Federal Division published a joint discussion of tomato diseases in Florida (24—185).

In 1924, the Federal Division of Truck Crop Insects began investigations of the pepper weevil in California. Later, the work was conducted under informal verbal agreement with the California Station and the Orange County Horticultural Commission, the latter furnishing quarters for the work for a time. The experiments are planned jointly by Federal and State officials. More recently, the State Station has paid part of the salary of an agent. Coöperative results were published (92—447) under joint authorship in 1934.

POTATO AND SWEET POTATO

The commercial product of the potato is a tuber or subterranean stem, and the sweet potato is an enlarged edible root. Much co-operative effort has been applied to the former but relatively little to the latter.

Potato

The status of the potato in coöperative investigations is different from that of most vegetable crops in that both production and protection studies have been made.

Production.—In California, the coöperation has been very limited. In 1923 and 1924 the Station Division of Truck Crops began varietal tests of potatoes in different sections of the State (9—287). The tests in Los Angeles County were in coöperation with the Extension Service, and those in Kern County in coöperation with the Federal Bureau of Plant Industry at its Cotton Field Station at Shafter.

In Colorado, a coöperative Potato Experiment Station was established at Greeley in 1915. The Board of Commissioners of Weld County furnished the land and a laboratory building. The Colorado Station furnishes financial aid and the Federal Office of Horticulture provides personnel and supervision. The Division of Cotton and Truck Crop Diseases coöperated in disease studies until merged. The Entomology Division of Truck Crop Insects also assisted. Several coöperative publications have resulted. In 1921, the State Station published a report of investigations to date (19—261). From 1920 to 1923, the Station Division of Chemistry studied the effect of nitrates on the composition of the potato (19—325). The time and rate of irrigating potatoes were published (92—118) in 1929, and the effect of irrigation water on viability and vigor of seed potatoes (92—216) in 1930, but covering experiments from 1921 onward.

In Maine, Federal-State coöperation in potato production and protection has been in progress for nearly twenty years. A Potato Experiment Station was established by the State Station in 1913 at Presque Isle, in Aroostook County. In about 1918, the Federal Office of Horticultural Investigations began coöperation in potato breeding and provided a greenhouse and potato-storage house for

use in the work (47—288). The influence of size of potato sets was investigated there (90—1248), the results being combined with data obtained in 1914 to 1919 in coöperation with the Virginia Truck Experiment Station. In a comprehensive testing of the influence of freezing seed potatoes on viability and yield (92—119), some of the work was done from 1922 to 1924 at the Maine Substation. New varieties developed and distributed for commercial production in this coöperative project have been described (93—276 and 374).

The Federal Office of Soil Fertility Investigations also coöperated with the Maine Potato Station from 1925 to 1929 on tests of concentrated fertilizers for potato (47—350) and on sources of nitrogen for potato fertilizers (47—354). Studies of the effect of handling methods on quality, conducted by the Maine Station and the Maine Development Commission, with coöperation from the Federal-State Extension Service and the Maine Department of Agriculture, were published (47—365) in 1933.

A few minor Federal-State coöperations have occurred. In Montana, potato experiments in irrigated rotations were published (60—263) in 1932. In South Carolina, experiments on certified seed of Irish Cobbler potato were conducted during 1924 and 1925 by the Station and the Federal Division of Horticulture (84—232). Several farm-management and marketing studies of potato have been discussed at appropriate points in the chapter on Agricultural Economics.

Protection.—An early and isolated instance of Federal-State coöperation in potato protection was with the Vermont Station in a study of resistance, published (121—87) in 1905. The principal coöperation in the study of potato diseases, especially mosaic diseases, has been with the Maine and Wisconsin Stations, although early histological studies of the potato plant (41—14:221) and of leaf roll (41—15:559), with the New York (Cornell) Station, were published in 1918.

Coöperation between the Federal Division of Cotton, Truck Crop, and Forage Crop Diseases and the Maine Potato Station was begun in about 1916. Studies of the influence of temperature and precipitation on the blackleg disease (41—13:507), and of the mosaic disease (41—17:247; 47—292) and its transmission (41—



19:315), appeared from 1918 to 1920. Other phases, such as leaf roll (47—297), spindle tuber (47—312), leaf roll, net necrosis, and spindling sprout (41—21:47), absorption of copper from soil (41—22:281), importance of degeneration diseases (47—316), and their natural spread (41—25:43; 47—331), were reported between 1921 and 1926. A study of tuber infection published by the Florida Station (24—187) in 1927 was in coöperation with the Maine Station, presumably because Maine-grown seed had produced infected plants in Florida.

Coöperation of the Federal Division with the Wisconsin Station on a study of late blight (147—37) was published in 1915. Studies of potato rhizoctonia (41—23), published in 1923, were coöperative with the Utah Station also. Effects of fertilizer on this disease (41—43) were issued in 1931. In the meantime, the Federal Division of Tobacco Investigations, coöperating with the Wisconsin Station on studies of tobacco mosaic, coöperated also on a classification of virus diseases of the potato (147—87).

Coöperation of shorter duration occurred in other States. The discovery of potato wart led to a three-way coöperation in a study issued jointly (90—1156) by the Federal Division, the Pennsylvania Station, and Pennsylvania Department of Agriculture in 1923, and a later publication (41—31:301) on soil treatments. In Wyoming, the Federal Division and State Division of Experiment Farms assumed joint authorship of a study of seed treatment for rhizoctonia control (148—152) in 1927. In Utah, a study of psyllid yellows begun in 1927 was jointly authored (41—46:189) in 1933.

In about 1926, the Federal Division began an extensive study of virus and virus-like diseases of potato and their control, both independently and in coöperation with the Montana, Oregon, and Utah Stations, which also conducted independent investigations. Results, both coöperative and independent, acquired by all four agencies during several years were published by the Federal agency (93—271) in 1933. In 1929, the Federal Division and the State stations of Idaho, Montana, Oregon, Utah, and Washington began a joint study of weeds as carriers of leaf roll and rugose mosaic (41—47:17).

The Federal Division of Truck-Crop Insects coöperated with the Wisconsin Station in a study of controlling potato leaf hopper

by spraying (146—334) and by dusting (147—82), from about 1920 to 1925, both studies being jointly authored.

Sweet Potato

The sweet potato has been the object of relatively little coöperation. In the North Carolina Station three Divisions, Agronomy, Botany, and Horticulture, jointly authored a discussion of approved practices for growers (72—263), in 1920. The Station and the Federal Division of Soil Fertility began coöperation in about 1922. A report on the effect of nitrogen and concentrated fertilizer on cotton and sweet potato was jointly written in 1929 and similar data for the years 1922 to 1928 (92—355) in 1932.

In about 1916 the Division of Truck-Crop Insects of the Federal Bureau of Entomology began coöperation with the Louisiana Station in a study of the sweet-potato leaf folder (90—609). This was followed in 1918—20 by a study of the control of the sweet-potato weevil in that State (46—188).

The publications listed in the Literature Cited at the end of this chapter which have been cited in this section on Vegetable and Truck Crops are Nos. 1, 8, 9, 12, 19, 20, 24, 26, 31, 37, 40, 41, 46, 47, 52, 60, 67, 68, 69, 70, 72, 76, 82, 84, 90, 92, 93, 97, 121, 146, 147, and 148.

10. FRUIT CROPS

FRUIT CROPS are exceedingly many and diverse. They may be grouped as citrus fruits, pome fruits, stone fruits, small fruits or berries, grapes, and subtropical fruits other than citrus. Citrus fruits include the orange, lemon, grapefruit, and many lesser kinds. Pome fruits include apple and pear. Stone fruits comprise peach, nectarine, and apricot, and plum and cherry. Berries or small fruits include the blackberry and raspberry, blueberry and cranberry, currant and gooseberry, and strawberry. Grapes include the American kinds, the European table grape, the raisin grape, and the so-called "currant" of commerce. The group called sub-tropical fruits is a miscellaneous mixture of many unrelated kinds such as avocado, date, fig, olive, and others less widely grown.

OFFICIAL AGENCIES

The Federal Department of Agriculture is the principal Federal agency concerned with fruits. A Division of Pomology was established in 1886, fifteen years before the creation of the Bureau of Plant Industry. A Division of Vegetable Physiology and Pathology was established in 1887 and within it a Plant Breeding Laboratory was set up later. This gave attention to fruit breeding, while other sections of the Division had to do with fruit diseases.

On or soon after the creation of the Bureau of Plant Industry in 1901, there were established Offices of Horticulture, Pomology, Plant Introduction, and Fruit Diseases, with another known as Crop Physiology and Plant Breeding. In spite of this pretentious name its work was chiefly on the breeding of citrus fruits and more recently on date production.

In the Bureau of Entomology a Division of Fruit Insects has been concerned continuously with the protection of fruit crops from insect pests. It has worked in close coöperation with the corresponding Division of Fruit Diseases in the Bureau of Plant Industry. These two Divisions have collaborated with the Insecticide and Fungicide Division of the Bureau of Chemistry, now in the Food and Drug Administration. They also worked in close relationship with the Federal Horticultural Board, which had charge of plant and insect quarantines from 1912 until it was merged in the Plant Quarantine Administration in 1928 and later into the Bureau of Entomology and Plant Quarantine. Other Federal agencies concerned with the protection of fruits are the Weather Bureau and the Division of Fruits and Vegetables in the Bureau of Agricultural Economics.

The principal State agencies in this field are the State Colleges of Agriculture, the State Departments of Agriculture, and, in some States, a State Plant Board, usually charged with quarantine and control activities. In each State College is the Agricultural Experiment Station and the Agricultural Extension Service. In the State Station the Division of Horticulture is concerned with fruit production and the Divisions of Plant Pathology and Entomology with fruit protection, the latter in coöperation with the corresponding control agencies in the State Department of Agriculture.

Most States have a single Division of Horticulture. California, however, has Divisions of Pomology, Viticulture, Subtropical Horticulture, Fruit Products, Truck Crops, and Landscape Design. The New York (Cornell) Station has Divisions of Pomology, Floriculture and Ornamental Horticulture, and Vegetable Crops.

Very few county or municipal agencies have activities in connection with fruits, except in California where each county has an agricultural commissioner charged with certain quarantine and control activities under the supervision of the State Department. Occasionally these commissioners take a minor part in production activities. In Washington, Chelan County has aided officially in fruit investigations, as discussed below under apple production.

GENERAL PRODUCTION

The Federal divisions concerned with fruit production have carried on extensive investigations for more than forty years. Almost all of these, however, have been conducted independently of State agencies. The work has been done either in commercial orchards and vineyards or on independent Federal field stations or laboratories. Since the merging of the various Plant Industry Divisions into one Division of Fruit and Vegetable Crops and Diseases, a considerable coöperative program has been developed, as will be noted in the discussion of the different fruit groups. A few earlier instances may be noted here.

In New York, the Division of Horticulture of the Cornell Station in coöperation with the Soil Survey Division of the Federal Bureau of Chemistry and Soils conducted studies of the relations of soils to fruit-growing and published (70—541) under joint authorship. Findings relating especially to the response of apple trees (70—550) were made public under State authorship in 1932.

Many coöperative studies related to fruit production have been presented in chapter 8 on Agricultural Economics. Surveys of the distribution of crops, involving coöperation with extension and statistical agencies, have been discussed under Special Production Surveys. Studies of fruit-farm management and costs of production have been discussed in the appropriate subsection of the Farm Management Section of the chapter noted. Investigations of fruit handling, transportation, and marketing problems will be found

in the section on Commodity Marketing in the chapter on Agricultural Economics.

Handling, Storage, and Transportation

The successive horticultural units of the Bureau of Plant Industry have been engaged on studies of the problems of fruit handling, storage, and transportation for many years. Much of this work has been done independently of other official agencies. Some of it has been done in coöperation with the Division of Fruits and Vegetables of the Bureau of Agricultural Economics and its predecessors. A few of the investigations have been in coöperation with State agencies.

The Plant Industry unit established a horticultural field laboratory at Los Angeles, California, in 1922, another at Lamanda Park in 1924, and a third at Fresno, California, in 1929. The first two were occupied with these commercial problems of both fruits and vegetables, while the Fresno laboratory had to do chiefly with the problem of table grapes. No one of these laboratories was in coöperation with any State agency in its investigations. At Fresno, office and laboratory space was obtained from the Fresno State College under a lease. In the recent reorganization of the Federal Division of Fruit and Vegetable Crops and Diseases, the work at Fresno has been continued but the laboratories at the other two points have been given up.

Conditions affecting quality of fruits.—From 1924 to 1926, the Federal Division and the California Station Division of Pomology coöperated in a study of the factors of shipping quality and of subsequent eating quality in pears and plums. The study of pears covered the entire Pacific Coast. In California, the Bureau of Fruit and Vegetable Standardization of the State Department of Agriculture furnished field transportation and other assistance. The results were published (92—140) under joint authorship in 1929. A similar study of handling Bosc pears from the Rogue River Valley in Oregon (78—228), in coöperation with the Oregon Station, was issued jointly in 1927. A third publication (92—450) containing data obtained from 1929 to 1931, principally in Washington, was coöperative with the Washington State Office of Horticulture.

A similar study of the relation of the maturity of California plums to quality appeared under joint authorship (8—428) in 1927. Early experiments in drying prunes made by the Oregon Station in coöperation with the Federal Bureau of Chemistry were published (78—205) in 1924. Studies on the processing and storing of dates in California were conducted and jointly authored in 1930 by the Federal Divisions of Horticultural Crops and Diseases and Drug Plant Investigations. California studies on evaporation of grapes (8—322), dehydration of fruits (8—330), and factors of dehydrator efficiency (8—337) were jointly authored in 1920—21 by the Station Divisions of Viticulture and Fruit Products, with financial aid from the Division of Pomology and equipment purchased with special funds from the State Board of Viticultural Commissioners. Investigations of the use of fruits in ice creams and ices (8—434) were jointly reported in 1927 by the Station Divisions of Dairy Industry and Fruit Products. A California study of precooling of fresh fruit and of the temperatures of refrigerator cars and warehouse rooms (8—496) was jointly authored by the Station Divisions of Pomology and Agricultural Engineering.

In the national research project on vitamins, arranged by the State stations and the U. S. Department of Agriculture, California was assigned studies on the vitamins of fruits. As California produces about 94 per cent of the dried fruits of the United States, Purnell Project No. 830 was established in 1927 to determine the effect of drying method on vitamin content. Under coöperative agreement between the University Department of Household Science and the Station Divisions of Viticulture and Fruit Products, studies have been made on the content of vitamin A (antixerophthalmic) and C (antiscorbutic) in dried and sulphured prunes and apricots (41—42:35) and on fresh and dried apricots (41—46:841), the latter being jointly authored.

In Georgia, the State Station and the Home Economics Department of the State College of Agriculture coöperated in a study of the vitamin content of peaches, as well as of several vegetables (26—167).

GENERAL PROTECTION

There has been little Federal-State coöperation in general fruit-crop protection, but more with reference to the diseases and insects of particular fruits. Within the Federal Department of Agriculture the Plant Industry Division of Fruit Diseases and the Entomology Division of Fruit Insects have coöperated very closely over many years on some problems. Their collaboration has covered the development of new and improved insecticides and fungicides, in which one or both often have collaborated with the Insecticide and Fungicide Division previously noted (41—40:1007; 92—162 and 198). This coöperation has extended to actual field operations in the control of fungus diseases and insect pests of various fruit crops.

The coöperation between the Federal Plant Industry Division and the Agricultural Economics Division of Fruits and Vegetables with the University of Chicago on problems of marketing and storage diseases of fruits and vegetables has been discussed under vegetable protection. In the field of fruit protection, they have published on the market diseases of apple, pear, and quince (97—168).

Within the State stations there are many instances of coöperation involving two or more divisions, such as horticulture, entomology, and plant pathology especially. A good example is found in the Michigan Station, where the Divisions of Botany, Entomology, and Horticulture have jointly issued publications on spraying practices for orchards (53—144 and 174) and on diagnosing orchard ills (53—164). In Ohio, a program of orchard spraying and pest control was developed by the Departments of Botany, Entomology, and Horticulture of Ohio State University and the corresponding divisions of the State Station at Wooster (76—500) in 1932. The consequent publication was issued also as *Bulletin 128* of the Ohio Federal-State Agricultural Extension Service.

Most fungus diseases are confined to a single fruit crop or group of related fruits. This is true also of most insect pests. Some troublesome insects, however, have a very wide range of host plants. The bacterial diseases known as crown gall and hairy root attack several kinds of plants but primarily are troublesome to the apple and therefore will be discussed under apple protection. In the

same way the larvas of the codling moth infest a very large number of different plants, while their principal damage to fruit crops is on the apple and pear and therefore they properly are discussed under protection of those crops.

On the other hand, the recently introduced Japanese beetle is an important and destructive pest of many fruit crops and of other plants as well. Coöperative investigations concerned with it, therefore, are properly presented here under General Protection.

Japanese Beetle Control

After the discovery of the Japanese beetle in the United States, the Federal Bureau of Entomology established a Division of Japanese and Asiatic Beetle Research and also a Japanese Beetle Laboratory at Riverton, New Jersey, in coöperation with the State Departments of Agriculture of New Jersey, Pennsylvania, and Delaware. Early studies, issued in 1923 and 1925, covered the fumigation of soils with carbon bisulfide and other organic compounds (68—380 and 410) as control measures for the Japanese beetle. A comprehensive bulletin on the feeding habits and control of the Japanese beetle (90—1154) appeared in 1923 and a discussion of its parasites in Japan and their introduction to the United States (90—1429) in 1926, the latter involving much assistance from officials and institutions of Japan. Later research on the repellantcy to the Japanese beetle of extracts made from plants immune to attack (92—299) appeared in 1932.

This last publication is an extreme illustration of the concentration of functions of different Federal bureaus in one Division of one Bureau. For instance, the collection and identification of the plants involved was done by entomologists rather than botanists, although the botanical classification of the hundreds of plants occupies ten pages. The preparation of the extracts also was the work of entomologists rather than of chemists in the Bureau of Chemistry or in the Plant Industry Division of Drug Plant Investigations.

A study of the Asiatic beetle in Connecticut (20—304) in 1929 was a joint product of the Federal Bureau of Entomology and the Station. A similar study of the bud moth (90—1273) was published in 1924. A comprehensive discussion of cankerworms, which attack

several fruit crops (90—1238), was based on coöperative investigations of the Federal Division of Fruit Insects and the Connecticut Station.

CITRUS FRUITS

The citrus fruits include the well-known orange, lemon, and grapefruit as well as such forms as the kumquat, lime, tangerine, and recent hybrids. For about forty years the Federal Bureau of Plant Industry has been investigating the production, improvement, and protection of citrus fruits. Almost all the work on production and improvement has been conducted on noncoöperative Federal field stations. Some of the investigations of citrus diseases and insects have been conducted under Federal-State coöperation or jointly by different State agencies.

Production

The Federal Division concerned with citrus production bore the anomalous name of Crop Physiology and Plant Breeding until its recent merger in the present Division of Fruit and Vegetable Crops and Diseases. It has had independent stations and operations from coast to coast, but principally in Florida and California.

In Florida, in 1932, the Station Divisions of Horticulture and Home Economics and the Federal Division named were joint authors of a study of type, variety, maturity, and physiological anatomy as affecting quality of citrus juices (24—243), although only part of the work was coöperative with the Federal agency.

In California.—In 1909, the Federal Office of Horticultural Investigations began the study of bud variations in citrus crops in California. Most of the work was done in commercial orchards near Riverside, the seat of the California Citrus Experiment Station. The surveys covered the Washington navel and Valencia oranges (90—623 and 624), the Marsh grapefruit (90—697), and the Eureka and Lisbon lemons (90—813 and 815).

After these preliminary surveys of bud variations, the propagation by buds from superior stocks was begun in coöperation with the Citrus Experiment Station, and progeny trees were grown on the station. Studies of bud selection as related to quantity production (41—26:319) and to quality (41—28:521) of the Washington navel orange appeared in 1923 and 1924. Progeny tests of limb

variation in the Valencia (90—1483) and Washington navel (92—123) oranges were published in 1927 and 1929. The Federal Bureau of Chemistry coöperated in determining the inheritance of composition in the last-named variety (92—163).

The Citrus Station has provided an office and furnishes the facilities of the station, including the experimental orchards, for this work. More recently, the Federal Department of the Treasury has provided an office in the Federal Building at Riverside. It should be noted here that the director of the Citrus Experiment Station does not regard this relation of the Federal and State agencies as truly coöperative. This view is held because the work, although done partly on the station property, is conducted entirely independently of the station in that the station has no part in the planning of the projects, in the manner of their execution, in formulating the conclusions drawn, or in preparing the results for publication. He regards the relation as restricted to the furnishing of certain facilities and services by the station.

A survey of orchard practices in growing citrus fruits in five counties of southern California (8—374) was conducted in 1923 as a joint project of the Federal-State Extension Service, the State Department of Agriculture, and the Citrus Experiment Station. In 1930, the Citrus Station collaborated with the Station Division of Forestry and the Agricultural Extension Service in a discussion of the effects of drying winds on citrus trees (8—484), the foresters discussing windbreaks and the extension men soil moisture, cultivation, and fertilization.

With the recent reorganization of the Federal Division, coöperative citrus investigations have been established at the Gulf Coast Substation of the Alabama Station. The more extensive work in Florida and California remains noncoöperative.

Protection

Protection of citrus crops covers physiological diseases, fungus and bacterial diseases, insect pests, and frost prevention.

Physiological diseases.—*Mottle leaf*: About 1912, a functional disturbance of orange and lemon trees, popularly called "mottle leaf," became increasingly prevalent in California. Investigations were begun by the Offices of Biophysical Investigation and Soil

Bacteriology and Plant Nutrition Investigations, with assistance from the Office of Alkali Plant Investigations, all of the Federal Bureau of Plant Industry, in some degree of coöperation with the California Citrus Experiment Station. The Federal workers were given office and laboratory facilities at the station but apparently no State worker took part in the study. The disease was found to be connected with humus deficiency in the soil. Numerous papers by representatives of the first two Federal Divisions were issued from 1916 onward. Studies of soil conditions (41—6:721; 90—499), fixation of ammonia (41—9:141), transformation and distribution of nitrogen (41—9:183), and response of citrus seedlings in water cultures and organic extracts (41—18:267) were made. Numerous other studies were conducted wholly independently of the Citrus Station.

Boron injury: Both the Federal Division of Western Irrigation Agriculture and the California Station conducted extensive independent investigations of boron injury to citrus groves, beginning in 1928. The Federal Division studied especially the boron content of irrigation water and the soil solution, sources of contamination of water supply, and boron tolerance by crops. The Citrus Station furnished to this Division office, laboratory, and greenhouse facilities (92—264), but there was no actual coöperation. The relation was essentially the same as in the mottle-leaf investigations.

Fungus diseases.—In 1929, the Federal Bureau of Plant Industry and the Bureau of Standards in the U. S. Department of Commerce jointly authored a research on the fungicidal action of ultraviolet radiation (41—38:159), as a surface disinfectant.

In 1912, a disease called gummosis appeared in California citrus orchards. The State Commission of Horticulture, predecessor of the State Department of Agriculture, immediately began investigations (12—2:601), with assistance from the commissioner of horticulture of Ventura County, and from the State Station through its Southern California Pathological Laboratory at Whittier and its Citrus Experiment Station at Riverside. Research in the organisms and their control was continued for many years at the Citrus Experiment Station, but apparently without coöperation with other agencies until assistance was received from the National Research Council for special tests of resistance (41—41:515), in 1929.

Federal and State agencies continued studies of handling and storage diseases of citrus fruits, but only occasionally in coöperation. In 1927, however, they were joint authors of a study of decay organisms (41—35 :925).

With the discovery of citrus canker in the southern States some twenty years ago there was immediately begun an intensive coöperative program of research and eradication. The Federal-State research project was coöperative between the Federal Division of Crop Physiology and Plant Breeding and the Alabama Station Division of Plant Pathology. All phases of the problem were studied, including resistance of wild and cultivated citrus species and varieties (41—14 :337, 19 :339 and 28 :227), overwintering of the organism (41—14 :523 and 33 :335), environmental influence on infection and development (41—20 :447), and effect of weather on world distribution and prevalence of both citrus canker and citrus scab (41—32 :147), all published between 1918 and 1926. Earlier papers on the citrus scab covered the susceptibility of citrus crops (41—24 :955) and the relation of environmental conditions (41—28 :241). Less extensive studies of citrus canker were made in the Philippine Islands in coöperation with the Philippine Bureaus of Agriculture and Science. These studies covered the susceptibility of citrus crops (41—15 :661) and the behavior of the organism in the soil (41—19 :189).

In the eradication of citrus canker the Federal quarantine and control agencies, then consisting of the Bureau of Entomology and the Federal Horticultural Board, coöperated fully with the comparable agencies in the infested States from Florida to Texas and with similar agencies in Arizona and California where the disease did not occur. The most extensive collaboration was with the State Plant Board of Florida, in which State the disease has been completely eradicated. The cleanup campaign in the less commercial States is being continued by the present Bureau of Entomology and Plant Quarantine.

The Plant Board was created by the Florida Plant Act of 1915. Five Divisions were established, namely: Citrus-Canker Eradication, Entomology, Nursery Inspection, Plant Pathology, and Port and Railway Inspection. The chief executive officer of the Board was made State Plant Commissioner and placed by law at the Uni-

versity of Florida, which provided office and laboratory space for his staff. The different Divisions coöperated fully with the State Station and the Federal Bureau of Plant Industry. The Port and Railway Inspection Division worked closely with the Federal Horticultural Board, the quarantine agency, the State Deputy Inspector having a Federal appointment, and working closely with the Federal customs officials also. In close coöperation between the Federal Department and the British and Bahaman Governments, a thorough survey of the Bahama Islands was made by an officer of the Plant Board, as was done also in Cuba.

Insect pests.—For nearly fifty years the Federal Bureau of Entomology has been conducting investigations of citrus insects in California on an increasing scale. The research has covered scale insects, mealy bugs, thrips, and citrus mites, as well as injury by the Argentine ant, katydids, and butterflies. Probably more than a hundred papers have been published, at least half of them on scale insects and thrips. Virtually all of this work has been independent of any official State agencies.

There is direct coöperation with the Federal Bureau of Chemistry which maintained a staff member with the Whittier Laboratory of the Bureau of Entomology in connection with chemical studies of fumigation and on resistance of scale insects to chemical poisons. There is no direct coöperation with the Citrus Experiment Station, although there are occasional staff conferences on the program and a purported, but apparently only partial, division of the field between the Federal and State research agencies. The State Department of Agriculture and the county commissioners of agriculture work in more or less informal coöperation with the State Station on citrus-insect problems. The State Station coöperates with county agencies on these problems. In providing ladybird beetles for biological control of mealybugs, the Supervisors of Los Angeles County provided buildings and equipment and Orange County operated a laboratory furnished by the growers through subscription, the Station working with both (8—509).

With the discovery of an infestation of the Mediterranean fruit fly in Florida a few years ago, Federal and State quarantine and control agencies coöperated intensively on an eradication campaign, liberal funds being supplied by the Federal Congress. In

anticipation of a possible invasion of California by this insect, the Federal and State authorities conducted a joint research in the possibility of sterilizing citrus fruit by heat (12—19:831 and 20:211). Studies were made also, by the Federal Bureau of Entomology, of the unrelated Mexican fruit fly (92—400 and 444), with assistance from official agencies in Mexico.

The development of chemical sprays and oil emulsifiers for them has been worked out coöperatively by the Federal Bureaus of Plant Industry and Entomology (90—1178) and by the Bureaus of Entomology and Chemistry and Soils (41—46:41 and 49:1).

Frost prevention.—The Weather Bureau of the U. S. Department of Agriculture maintains a fruit-frost forecasting service in California, especially in those districts producing citrus fruits, all of which are very susceptible to frost injury. This has been fully discussed in chapter 2 on Climate. There has been Federal-State coöperation in a comprehensive survey of orchard-heating practices, costs, and results (8—398) and also in a testing of orchard heaters (8—442). Following the freeze of January, 1913, the Federal Office of Horticultural Investigations and the Citrus Experiment Station made a joint study of the effect of frost injury on citrus fruit (8—304; 90—821).

POME FRUITS: APPLE AND PEAR

The apple and pear were among the earliest introductions of European fruits to colonial America and have been important items in the fruit industry ever since. There has been little coöperation by official agencies in production studies of these crops, but more in protecting them from fungus diseases and insect pests.

Production

Coöperative statistical studies of production and distribution of apples and pears (90—485 and 822) have been discussed in chapter 9 on Agricultural Economics, under Special Production Surveys. Similar coöperative studies on farm management and costs of production and on marketing have been presented in the chapter mentioned, under Farm Management and Costs of Commodity Marketing, respectively. A few coöperative studies in the more definite field of orchard production have been made.

In California.—The Federal Office of Pomological Investigations, now included in the Division of Fruit and Vegetable Crops and Diseases, long maintained noncoöperating horticultural field offices in California. Those devoted to studies of fruit handling and transportation already have been discussed. Between 1918 and 1922 such field offices were located independently at Sacramento, in coöperation with Stanford University at Palo Alto, and with the U. S. Cotton Field Station at Shafter. These two agencies provided land and office and laboratory space. The work done at these stations covered not only the pome fruits but stone fruits as well, and nuts also at the Sacramento office.

Stimulation to apple trees having been caused, apparently, by certain crude-oil-emulsion and other sprays, the Federal Division and the horticultural commissioner of Santa Cruz County conducted experiments, and jointly authored the results, in winter spraying of apple trees with solution containing nitrate of soda (41—1:437) in 1912–13.

In other States.—A few Federal-State and interstate coöperations in apple and pear production have been noted, some in the east and some in the west.

In Iowa, the Station Divisions of Pomology and Chemistry jointly studied the physiological and chemical changes in apples during storage (40—91 and 131). In Missouri, a peculiar interstate coöperation was effected. A study of bud selection in apple and strawberry, begun by the Missouri Station in 1895 and continued for twenty-three years, was published (59—39) in 1920, with five years of similar data from the Oregon Station included through the courtesy of the latter station, primarily because of the transfer of the Oregon researcher to Missouri. Studies of the ripening, storage, and handling of apples, conducted coöperatively by the Federal Division and the State Stations of Iowa, Massachusetts, Michigan, New York (Cornell), and Ohio, were published (90—1406) in 1926.

In New Hampshire, a similar interstate coöperation was arranged. Experiments on the resistance of apple roots to low temperatures were conducted by the Station from 1912 to 1923, and similar experiments were conducted by the Wisconsin Station, both being published by New Hampshire (67—27) in 1924. The Station

Divisions of Chemistry and Horticulture made a coöperative arrangement in 1920 for a joint study of the effect of shading and ringing on the composition of apple and peach twigs (67—23), and, later, on the composition of fruit spurs (67—29, 41, and 42).

In the western States some coöperative activities have developed in Montana, Oregon, and Washington. In Montana, the Station Divisions of Chemistry, Botany, and Horticulture jointly authored a study of apple-tree growth as influenced by soil conditions in the Bitter Root Valley (60—241) in 1931. In Oregon, the State Station and the Federal Bureaus of Agricultural Engineering and Plant Industry, under a coöperative arrangement, studied the irrigation of pear orchards at Medford (92—432) from 1930 to 1932. These irrigation experiments are being continued.

In Washington, the Station Division of Horticulture, in official coöperation with Chelan County, has studied the effects and remedies for orchard crowding (142—200), the pollination of deciduous fruit trees (142—223), the relation of foliage to fruit size and quality in apple and pear (142—249), and irrigation of orchards by sprinkling (142—268), the latter including collaboration of several station divisions and the Federal Office of Fruit Diseases. From about 1920, Chelan County paid the salaries and maintenance expenses of horticultural and entomological workers while the State Station furnished supervision. The Station Divisions of Chemistry and Horticulture and the Federal Division mentioned also coöperated in a study of the physiological and chemical characteristics of maturing apples as related to time of harvest (142—205) in 1926.

Protection

Rather more Federal-State and interstate coöperation has occurred in the protection of apple and pear from fungus diseases and insect pests than was the case in the production of these crops. In most cases the coöperation has been of a temporary or spasmodic nature rather than a long-continued joint enterprise.

In California.—In the many years of protective studies of apple and pear in California by plant pathological and entomological agencies, Federal and State, only a few instances of coöperative activities are found. The control of powdery mildew of the apple in Santa Cruz County was studied coöperatively in 1910—11 by the

Federal Division of Fruit Diseases and the county horticultural commissioner and jointly authored (90—120) in 1914. In 1930, the State Department of Agriculture entered into coöperation with the Federal Bureau of Plant Industry and the agricultural commissioner of Santa Cruz County on heat treatments of apples for mealy-bug control (12—20:389), the treatments being applied in a coöperatively conducted plant at Lamanda Park.

An outbreak of pear thrips in Santa Clara County caused the Federal Bureau of Entomology to establish a field laboratory there in 1904 and another in Contra Costa County in 1908. Assistance and facilities were received from the county supervisors and horticultural commissioners (90—173). Progress reports covering life history and habits (109—68) in 1904—5, studies of control (109—80:51) in 1905—8, and additional control measures (111—131) in 1908—10, were published by the Federal Bureau.

In about 1900, the pear orchards of the San Joaquin Valley were almost wiped out by an epidemic of pear blight. In the spring of 1904 a similar epidemic started in the Sacramento Valley. After conferences, a coöperative arrangement was made whereby the State Station, the State and County Commissioners of Horticulture, and the Federal Division of Fruit Diseases agreed to coöperate as fully as possible in suppressing the epidemic by the methods recommended by the Federal Division, which furnished leadership and numerous inspectors. The State legislature made funds available, the State Commissioner of Horticulture aided in the educational campaign, and the county horticultural commissioners coöperated heartily in the control demonstrations and provided some funds for personnel (8—184). In about 1928, pear blight again became prevalent and the same State agencies began coöperation in its control (12—19:465). The infestation increased and the Federal Division of Fruit and Vegetable Crops and Diseases again was asked to help the State agencies (12—22:350).

In other States.—The major campaigns for protection of apple and pear have been waged against crown gall and hairy root, the codling moth, and other miscellaneous insects. The three-way coöperation on market and transit diseases of fruit and vegetables by the Federal Divisions of Fruit and Vegetable Crops and Diseases and Fruit and Vegetable Marketing, with the University of

Chicago, described fully under Vegetable Protection, covers apple diseases among others. Two publications thereon have been issued (90—1253; 41—41), in 1924 and 1930.

Crown gall and hairy root: These two bacterial diseases have been studied chiefly on apple, although they attack many other crops. In Iowa, the State Divisions of Plant Pathology and Horticulture jointly studied crown-gall control on apple grafts in the nursery (40—62). As noted below there was some coöperation with the Wisconsin Station.

In Wisconsin, the Federal Division of Fruit and Vegetable Crops and Diseases has been coöperating for ten years or more with the Station Division of Plant Pathology in studies of hairy root and crown gall on the apple, the first general study (41—41:507) being coöperative also with the Iowa Station. Later studies have covered single-cell isolations of both organisms (41—41:541), life history of hairy root in relation to pathogenicity (41—48:857), seasonal development of both diseases (41—48:887), and the occurrence of both diseases on root-grafted trees (41—48:913), all jointly authored and the last three published in 1934.

Codling moth: The larvas of this insect, while attacking many different kinds of fruit, are most destructive to the apple. The Federal Division of Fruit Insects has coöperated with several States in studies of its life history and control. Studies of fluorine compounds for controlling the codling moth were authored jointly by the Bureaus of Entomology and Chemistry (92—373). Investigations of the one-spray method of control of codling moth and plum curculio were made jointly by the Federal Divisions of Fruit Insects and Fruit Diseases (109—80 and 115) from 1909 to 1911.

In Arkansas, the life history of this insect was studied jointly by the Federal Division and the State Station (4—189) from 1917 to 1921. In Colorado, the coöperation was with both the Station and the State Entomologist (19—268 and 322), in the Grand Valley, from 1914 to 1919, the life-history studies (90—932 and 959) being published by the Federal agency. In Delaware, the life-history studies, from 1919 to 1920, were jointly authored but were published by the Federal agency (92—42) in 1928. In Kansas, control methods were jointly authored by Federal and Station Divi-

sions (42—263) in 1932. In Missouri, the Station summary of twenty years of work (58—334) in 1934 acknowledged the coöperation of several county agents, the Station Division of Horticulture, and the Arkansas Fruit-Insect Laboratory of the Federal Bureau. In Virginia, the State Station republished (139—188) a Federal publication on the use of lime-sulphur sprays in northern Virginia (122—54), in order to give it a wider publicity among Virginia growers.

In Washington, the question of the removal of arsenical spray residues from mature fruit became acute in about 1925, because of foreign fears of arsenical poisoning. The Station Divisions of Horticulture, Chemistry, Plant Pathology, and Engineering collaborated and jointly reported studies of residue removal (142—213 and 226) in 1926 and 1927, with some coöperation from Chelan County and the Federal Division of Fruit Diseases. More recently the same Engineering and Horticultural Divisions coöperated in developing the Station experimental fruit washer (142—285). In 1924, the Federal Division of Fruit Diseases and the Station Division of Entomology published on the life history of the codling moth in the Yakima Valley (90—1235) and in 1929 the Station published results of spraying studies (142—232), conducted in coöperation with Chelan County. Later the Divisions of Entomology, Horticulture, and Chemistry collaborated and jointly authored experiments on oil sprays for dormant (142—247) and summer (142—252) use.

Miscellaneous insects: Several minor coöperations on the protection of apple and pear from other insects have been noted. In Arkansas, studies of apple leaf hopper in the Ozarks were carried on from 1918 to 1929 by the Federal Division of Fruit Insects and the Station Division of Entomology and jointly reported (92—263) in 1931. In Connecticut, studies of the apple skeletonizer were conducted independently by the State Station and the Federal Division but were combined in a single State publication (20—246) in 1923 at the suggestion of the Connecticut Station. In 1917—22, coöperative studies were made by these agencies on the apple maggot (92—66).

In New Hampshire, the Station published its investigations of spraying against leaf miners, mostly on apple (67—17), with Ohio

data obtained on the quince miner through a coöperative arrangement with the Ohio Station. Studies of the apple flea weevil, made independently by the Ohio Station and the Illinois Natural History Survey, were combined into one publication (76—372) for the sake of greater completeness. The combined data also were published later by the Illinois Survey. In Virginia, the State Station and the State Crop Pest Commission worked closely together in studies of the oriental fruit moth (139—234) and of apple diseases in northern Virginia (139—245) in 1924 and 1926.

STONE FRUITS

The stone fruits include peach, apricot, and nectarine in one group, and plum, prune, and cherry in another. No coöperative studies of the production of these fruits appear to have been made other than those discussed or referred to earlier in this section in connection with problems of handling and transportation or under vitamin studies.

In California, from 1923 to 1928, the Station Divisions of Pomology and Irrigation Engineering coöperated in experiments in the irrigation of peaches, and from 1926 to 1928 the Division of Fruit Products determined quality (8—479), the results being jointly authored in 1930. Under the new Federal coöperative program, these fruits are being improved in coöperation with the California Station, at Davis, while peach production is studied coöperatively in North Carolina.

Protection

A few minor and scattered coöperative studies have been made of the protection of stone fruits from fungus diseases and insect pests.

In California, the codling moth as a pest of stone fruits was discussed by the State Station and State Department of Agriculture (12—18:304) in 1929. Control measures for the peach twig borer were jointly recommended recently by the State Station and State Department of Agriculture (12—21:232), the Department doing the field work and the station the laboratory work, under agreement.

In Georgia, peach-disease control was discussed by the Georgia Station (26—139), in about 1920, with assistance acknowledged from the Federal Bureau of Markets and the Georgia State Board

of Entomology in obtaining data. Experiments in the control of the plum curculio, brown rot, and scab of the peach in Georgia were jointly authored by the Federal Divisions of Fruit Diseases and Fruit Insects and the Georgia Entomology Board (90—1482) in 1927.

In Mississippi, dusting and spraying of peaches was conducted jointly before 1920 by the Federal Bureaus of Entomology and Plant Industry in coöperation with the Mississippi Station (57—195) and the State Plant Board, at Holly Springs Branch Station. In Arkansas, a study of the bacterial spot disease of the peach and other stone fruits was conducted by the Federal Division from 1928 to 1930 in the laboratories of the Station Division of Plant Pathology (92—273).

SUBTROPICAL FRUITS

Subtropical fruits, other than citrus, include avocado, date, fig, and olive. Very little coöperative research has been conducted on any of these crops or their diseases and pests.

Date Production and Protection

The date-production work of the Federal Department has been done by the Division of Crop Physiology and Plant Breeding. In 1904, the Mecca Land Company assigned to the University of California a tract of fifteen acres, which was made available to the Federal Division for date production and improvement. There was no coöperation with State agencies. In 1907, a tract of twenty acres near Indio, in the Coachella Valley of Southern California, was deeded to the Department and became the U. S. Experiment Date Garden. The studies were wholly noncoöperative with official State agencies.

In coöperation with the Office of Indian Affairs, Department of the Interior, dates are grown on two reservations of the Mission Indian Agency, primarily to improve the reservation dietary. Experiments on processing and storing dates in California were jointly promoted by the Federal Division named and the Division of Drug and Related Plants (92—193) in 1930.

Two different scale insects were introduced with imported date offshoots from 35 to 45 years ago. By 1913 they had become so destructive in three States that research was begun and a Federal

quarantine laid. Extermination was attempted by joint efforts of the Federal Horticultural Board and the Bureaus of Entomology and Plant Industry, with the assistance of the California State Department of Agriculture. Discovery of extensive new infections in 1927 caused a reorganization of the work. With the setting up of a Division of Date-Scale Control in the newly created Plant Quarantine and Control Administration in 1928, the work of eradication has gone forward vigorously. The program is planned and conducted in informal coöperation with the California State Department of Agriculture, each furnishing personnel. The Bureau of Entomology and Plant Quarantine maintains research in date-scale life history (41—21:659), methods of disinfection of date palms, and scale structure (92—404), the latter acknowledging assistance from the University of California, Stanford University, and the U. S. National Museum.

Avocado and Fig

A California Citrus Station study of the avocado sun-blotch disease, by the Federal Divisions of Horticulture and Plant Pathology, was published (12—20:447) by the State Department of Agriculture. An avocado moth was described by the Federal Bureau of Entomology and published (12—18:276) by the State Department.

Studies of an internal rot (31—2:287; 9—311) and injurious insects (93—157) of the fig have been conducted by the appropriate Federal or State divisions since 1923. In 1927 a Fig Clean-up Commission was appointed, with representatives of Federal, State, and county research, extension, and control agencies.

In North Carolina, a study of the green June beetle or figeater (72—242) was made jointly by Federal and State Divisions.

GRAPES

For many years the Federal Office of Horticulture and its successor units in the Bureau of Plant Industry have conducted extensive independent investigations of muscadine grapes in the South and of European grapes in California. Very recently the production and improvement of muscadine grapes has been made coöperative with the State Station, at the South Mississippi Branch Station at

Poplarville; with the North Carolina Coastal Plain Substation at Willard; and with the South Carolina Sandhill Substation at Columbia.

In California

Independent Federal investigations of grape production and improvement in California (121—172; 90—209), including handling (93—83) and storage (90—35), began at least as early as 1903. In that year an independent vineyard was established at Fresno and a similar one at Oakville in Napa County. From 1905 onward, similar but smaller vineyards were established in other areas until a total of twelve was reached. A minor study of resistant grape stocks was begun in connection with nursery-stock investigations conducted on the U. S. Cotton Field Station at Shafter. In 1923, the two large experimental vineyards first named were purchased by the Federal Bureau. In the recent reorganization these independent vineyards have been discontinued and the work with table grapes in California concentrated at Fresno.

An independent Federal study of grape diseases on the Pacific Coast was published by the Federal Division (91—30) in 1895. The grape phylloxera has been under investigation in California for three quarters of a century. Recent studies of the insect by the Federal Bureau of Entomology (90—903) and of soil relations (92—20) by the Federal Bureau of Soils and the State Department of Agriculture were somewhat coöperative, but study of resistance (92—146), by the Bureau of Plant Industry, was non-coöperative.

In 1931, the California Station, the State Department of Agriculture, the Federal-State Extension Service, and county farm advisors and county agricultural commissioners from grape-growing areas developed a coöperative program for control of the destructive grape leaf hopper. Joint recommendations of the two State agencies were issued (12—21 :225) in 1932. Recently the Station and the Extension Service through county advisors worked together on control of black measles of the vine (9—303) and the State Department and the Station on the red spider (12—19 :452).

In Other States

A few minor coöperations have occurred in grape production and the control of grape diseases and pests in States other than Cali-

fornia. The Oregon Station, in coöperation with the Federal Division of Western Irrigation Agriculture on the Umatilla Branch Station, studied grape production under irrigation for eastern Oregon (78—126) in 1926. From 1916 to 1918 the Federal Bureau of Entomology coöperated with the Ohio Station in a study of the control (90—837) and of the life history (90—911) of the grape borer. In Minnesota, the Station Divisions of Horticulture, Entomology, and Plant Pathology coöperated in a study of grape growing (55—297), including grape protection. In a recent study of the biology and control of the black vine weevil, the early portion was made coöperatively by the Federal Bureau of Entomology and the Pennsylvania State Bureau of Plant Industry (92—325).

SMALL FRUITS

The small fruits comprise several distinct groups, including blackberry and raspberry, currant and gooseberry, blueberry and cranberry, and strawberry.

Production

Relatively few coöperative studies have been made in the production of any of these small-fruit crops except through interdivisional coöperation within a State station. For instance, in Ohio the production and protection of raspberries and blackberries was jointly investigated, but in separate sections, by the Divisions of Horticulture, Plant Pathology, and Entomology. Federal-State coöperation in Oregon at the Umatilla Branch Station resulted in a publication on small-fruit culture on irrigated sandy soil (78—142) in 1927. A case of interstate coöperation occurred in the publication in 1920 by the Missouri Station (59—39) of a study of bud selection with special reference to the apple and strawberry, which included data covering twenty-three years of results at the Missouri Station and five years of results from the Oregon Station, the latter Station transferring its data to the former with a member of its staff. The Federal Divisions of Fruit and Vegetable Crops and Diseases and Tobacco and Plant Nutrition conducted coöperative experiments, between 1923 and 1932, on the responses of strawberry varieties and species to variations in the daily light period (92—453).

In an extensive study of cranberry production the Federal Di-

vision of Horticultural Investigations and the Massachusetts and Wisconsin Stations jointly authored studies of establishing cranberry fields (91—1400), managing cranberry fields (91—1401), and cranberry harvesting and handling (91—1402), all in 1924.

In studies of the frozen-pack method of preserving berries in the Pacific Northwest (92—148), the Federal Divisions of Horticultural Crops and Diseases and Food Investigations, the latter in the Food and Drug Administration, coöperated with the Western Washington Substation from 1924 to 1926, with publication in 1930 under joint authorship of the Federal Divisions. At present, coöperative Federal-State investigations of breeding small fruits are scheduled at the Oregon Station.

Protection

Except for the cranberry, there has been but little coöperative investigation of the diseases of small fruits. In the new coöperative Federal program, small-fruit diseases will be under investigation at the State Station and East Wareham Substation in Massachusetts, at the Cranberry Substation, Pemberton, New Jersey, and at the Coastal Plain Substation at Willard, North Carolina, the studies being devoted chiefly to cranberry diseases.

In North Carolina, the Station and the Federal Division of Fruit Diseases jointly published a study of dewberry anthracnose and its control (72—248) in 1926. In Mississippi, the State Station and the Federal Division, together, studied the crown-gall organism in relation to disease in red raspberry (41—48:761), and published in 1934.

The Federal Division of Deciduous Fruit Insects conducted research on the blueberry maggot (92—275) in Maine from 1925 to 1929 and expressed appreciation of the coöperation of the Maine Station and the State Department of Agriculture, and of chemical analyses of arsenical residues by the Federal Bureau of Chemistry. In experiments on dusting by airplane and ground machine (93—123), they had assistance from the Federal Division of Agricultural Engineering.

Cranberry diseases have been investigated by the Federal Division of Fruit Diseases in coöperation with several State Stations, including Massachusetts, New Jersey, North Carolina, Wisconsin,

Oregon, and Washington. In Massachusetts, a study of end rot (41—11:35) appeared in 1917 and of cranberry spoilage after harvest (49—180; 90—714) in 1917 and 1918. Studies on the Pacific Coast from 1922 to 1925 were in coöperation with the Oregon and Washington Stations (90—1134). In New Jersey, the Federal Division and the State Station jointly authored a report on a factor of varietal resistance to the false-blossom disease (41—47:583) in 1933. Other studies were made in coöperation with the Wisconsin Station. In 1931, the Federal Divisions of Mycology and Disease Survey and Fruit and Vegetable Crops and Diseases authored jointly an extensive summary of the fungus diseases of the cultivated cranberry (92—258), acknowledging coöperation of the experiment stations and departments of agriculture in cranberry-growing States.

The publications in the Literature Cited at the end of this chapter which have been cited in this section on Fruit Crops are Nos. 4, 8, 9, 12, 19, 20, 24, 26, 31, 40, 41, 42, 49, 53, 55, 57, 58, 59, 60, 67, 68, 70, 72, 76, 78, 90, 91, 92, 93, 97, 109, 111, 121, 122, 139, and 142.

11. NUT CROPS

THE PRINCIPAL NUT CROPS in the United States are almond, peanut, pecan, and Persian walnut. Wild nut crops include butternut, black walnut, chestnut, and hazelnut, though the chestnut tree is being exterminated rapidly by the chestnut blight. The peanut has been fully discussed in the section of this chapter concerned with forage crops, and no further presentation will be made.

OFFICIAL AGENCIES

Nut-crop investigations in the Federal Bureau of Plant Industry have been a part of the Division of Fruit and Vegetable Crops and Diseases and its predecessor units. The diseases of nut crops have been studied to some extent by the Plant Industry Office of Fruit Diseases, now merged in the Division mentioned above. Investigations of nut insects have been the concern of the Federal Division of Fruit Insects.

In the State stations the divisions of horticulture, plant pathology, and entomology are the ones primarily concerned with these crops.

PRODUCTION

California is the chief producer of nuts, growing 98 per cent of the almonds and a large share of the Persian walnuts of the country. When the former Federal Division of Horticultural Investigations established an independent Horticultural Field Office at Sacramento, in 1918, one of the two major projects was nut culture and it has so continued. In 1925, certain phases of the work were made coöperative with the University of California (College of Agriculture) Station Division of Pomology under a simple written agreement which provided that the station facilities at Davis might be used by the Federal agency for growing its progeny trees. The University furnished land and equipment, the Division furnished the basic material. In the recent reorganization of the Federal Division this coöperation was maintained.

Almond

Almond varieties in the United States were described (90—1282) in 1924 from the independent Federal investigations just noted. They are included in the later coöperative investigation in California. In 1928, almond crops and prices were discussed in print by the California Station (8—453), through extension specialists in agricultural economics, with assistance from the Station Division of Agricultural Economics, the Federal Division of Fruits and Vegetables, and the Bureau of Foreign and Domestic Commerce in the Department of Commerce.

Walnut

In California the Federal-State coöperation at Davis now includes walnut breeding. The walnut supply and price situation were discussed (8—475) in 1929 by the Station Division of Agricultural Economics, with assistance from the Federal Divisions of Crop Estimates, Fruits and Vegetables, and Statistical Research of the Bureau of Agricultural Economics, the California Crop Reporting Service, the Federal Bureau of Foreign and Domestic Commerce, the Interstate Commerce Commission, and many county agricultural commissioners.

The Federal Bureau of Entomology has made independent in-

vestigations of walnut aphids in California (90—100), beginning in 1911. The codling moth, discussed under apple protection, is a walnut pest in California. In 1918, an outbreak of this insect in southern California brought a special appropriation to the State Department of Agriculture which allotted one half of the sum to the State Station for research (8—402), conducted from 1919 to 1921. An outbreak of walnut husk-fly in about 1929 brought prompt agreement of State agencies on a division of responsibility. The Station was charged with research, part of which was promptly published by the State Department of Agriculture (12—19:249 and 20:230, 384, 682). The State Department was charged with quarantine, control, and eradication in coöperation with the agricultural commissioners of Los Angeles and San Bernardino Counties (12—20:384). The Station imported parasites from abroad in 1931.

In Oregon, the other walnut-producing State, the Station Division of Farm Management and the Federal Division of Vegetable Crops and Diseases jointly published a study of costs and practices in establishing walnut orchards in Oregon (78—315) in 1933. At the same time, the Station and the Federal Division published data on walnut production in Oregon (79—108).

Pecan

There has been little coöperation in pecan research. In Georgia, the Station Divisions of Horticulture and Botany collaborated in a study of unfruitfulness in the pecan (26—148) in 1928. An economic study of the pecan industry (92—324) was made in 1928—30 and jointly authored by the Federal Agricultural Economics Divisions of Crop Estimates, Farm Management, and Fruits and Vegetables, in coöperation with the Alabama State Department of Agriculture and the State Colleges of Agriculture in Florida, Georgia, Louisiana, and Mississippi. Soil and orchard management in relation to pecan rosette (90—1378) was jointly investigated in 1926 by the Plant Industry Divisions of Soil Fertility and Fruit Diseases.

Chestnut

During the years while chestnut blight was steadily destroying the chestnut forests of the eastern United States, there was con-

siderable Federal-State coöperation in research in the organism, the method of its distribution, including birds as carriers (41—2:405), and the possibility of combating its spread. The endeavor was unsuccessful, however, and the chestnuts are gone.

12. ORNAMENTAL PLANTS

ORNAMENTAL PLANTS may be grouped loosely as flowers, perennial vines, shrubs, and trees. There is no sharp line between these groups.

In the Federal Bureau of Plant Industry the work on ornamental crops has been done by the Division of Fruit and Vegetable Crops and Diseases and its predecessor units. In the Bureau of Entomology the work on these crops has been variously assigned. In the State stations the division of horticulture usually includes ornamentals and the divisions of entomology and plant pathology give them protection. In a few stations, as in California, Michigan, New Jersey, New York (Cornell), etc., there are divisions of landscape design or of ornamental horticulture. Where both a division of horticulture and a division of landscape architecture are found, there may be coöperation between them, as in Michigan, where they have jointly prepared information on rock gardens (53—228).

PRODUCTION

In North Carolina, in 1930, the State Department of Agriculture and the Federal Division jointly issued a discussion of daffodils for eastern North Carolina.

PROTECTION

In Mississippi, the Station Division of Plant Pathology and the State Plant Board collaborated in preparing a bulletin on the diseases of ornamental plants (57—261) in 1928.

At the Maryland Station the Federal Bureau of Entomology co-operated in a study of the rose midge (90—778). In coöperation with the Pennsylvania Department of Agriculture the Federal Division of Fruit Insects published on the strawberry rootworm as a pest of roses (90—1357).

In Virginia, the Federal Division of Horticultural Crops and Diseases coöperated with the Truck Experiment Station in a study

of poppy blight (41—40) in 1930. The Station Division of Entomology and the Office of the State Entomologist collaborated in 1923—24 in a study of the biology and control of a mealy bug on the umbrella catalpa tree (140—29). In 1934, the New Jersey Station and the Federal Division jointly authored a study of a bacterial disease of Boston ivy (41—48:807).

The publications listed in the Literature Cited at the end of this chapter which have been cited in these sections on Nut Crops, and Ornamental Plants are Nos. 8, 12, 26, 41, 53, 57, 78, 79, 90, 92, and 140.

13. SUMMARY OF COÖPERATION

IN THE PRODUCTION and protection of crop plants, two Federal Bureaus are chiefly concerned. Plant Industry is charged with crop production and improvement, and with the control of fungus, bacterial, and mosaic diseases. The present Bureau of Entomology and Plant Quarantine is charged with protecting plants from insect enemies. Both have exceedingly extensive field activities in the various States. The Bureau of Biological Survey has responsibility for helping to protect crops against rodents and birds and its activities in this field usually are coöperative.

Other Bureaus assist in special phases of the Federal work. Chemistry and Soils aids in determining composition and quality of crops and soils. Agricultural Economics coöperates in economic studies of such farm machinery as the tractor and combine, of grain quality as affected by handling, of cotton ginning in relation to quality, and of control of market and transit diseases of vegetables and fruits. Agricultural Engineering coöperates in testing new types of machinery, such as the combines, fertilizer distributors, and cotton gins.

Federal-State coöperation has varied widely with the Federal agencies involved. Within the Bureau of Plant Industry, the widest possible extremes, from virtually complete coöperation with State agencies to almost complete noncoöperation, have existed through the past thirty to forty years. Recent reorganizations, however, are greatly increasing the scope of coöperation. The Bureau of Entomology in general has been a noncoöperative bureau, especially in its research units. Those concerned with quarantine and similar control measures were more likely to coöperate.

Of all Plant Industry units having extensive field activities, the Division of Cereal Crops and Diseases has been the most consistently coöperative with the States and with other Federal units over the longest period of years. Coöperation in grain investigations was begun before the Bureau was formed in 1901. From about 1905 onward, this Division expanded its field activities rapidly and with increasing coöperative relations until by 1922 all field work was in coöperation with the State stations. In this movement for Federal-State coöperation in field studies it was a leader and has been so referred to by Federal and State officials in public addresses and conferences. It presents also some instances of special and unique coöperative relations in addition to its regular program. In its wheat-improvement program it has organized coöperative regional programs with groups of States, and in flax extension has published with as many as four States in a single publication. Another extensive regional coöperation was in the barberry-eradication campaign to protect cereal crops. International coöperation with many agencies in Canada, as well as with nearly all States, was entailed in compilations of varietal studies of barley.

The Division of Tobacco Investigation has coöperated with the States, and since about 1906 has carried an extensive program of field studies on Federal-State tobacco substations. The Division of Mycology and Disease Survey depends largely on State collaboration for its annual survey of the distribution and destructiveness of plant diseases. The Division of Seed Investigations has but few field laboratories but all are in coöperation with State stations or State departments of agriculture. Citrus Canker Eradication conducted its research in coöperation with the Alabama Station and shared its program of eradication with many States.

Other Divisions, such as Forage Crops and Diseases, Dry Land Agriculture, and Drug and Medicinal Plants, probably have had about half of their field activities in State coöperation during approximately the past twenty years. Still other Divisions, such as Fruit Diseases, Horticulture and Pomology, Sugar Plants, Vegetable and Forage Crop Diseases, and Western Irrigation Agriculture, have coöperated fully with State agencies in a few instances, but have conducted most of their work independently. The

Federal Division of Chemistry collaborated with several States in tests of sugar beets from 1888 to 1904 and stated this coöperation plainly and frequently in resulting publications.

The Divisions of a fourth group, including Biophysical Investigations, Cotton, Rubber, and Other Tropical Plants, Crop Physiology and Plant Breeding, and Egyptian Cotton Breeding, were almost entirely non-coöperative. It probably is not merely a coincidence that all of them have been merged into other units of the Bureau.

In the Bureau of Entomology several Divisions have coöperated on some specific or local problems but rarely on a general program. The total of coöperation forms but a small percentage of the total activities of the Bureau before the reorganization of 1928 and thereafter. The Division of Fruit Insects collaborated with the Plant Industry Division of Fruit Diseases and the Bureau of Chemistry on extensive tests of spraying compounds and methods and with States on codling-moth control. In quarantine and control activities, as with the corn borer, Japanese beetle, and Mediterranean and Mexican fruit flies, there were extensive Federal-State relations.

Examples of Federal-State-county coöperation occur most frequently in California, where each county has an agricultural commissioner with authority in quarantine and control of fungus and insect pests. In Washington, Chelan County has coöperated extensively with State Station and Federal agencies in problems of orchard management, mostly with apples.

Examples of interstate coöperation, without the coördinating influence of any Federal agency, are noted under flax and apple production.

Many cases of interdivisional coöperation within a State station have occurred, and examples involving three or more divisions are recorded under fruit production and protection, and elsewhere.

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From 1894 to 1928 the statistical and other data were for the year named in the title and the volume was published in the following year. Beginning with 1930 the year in the title is the year of issue and the contained data are for the previous year, a most confusing condition. Because of this change there is no volume bearing 1929 in its title.

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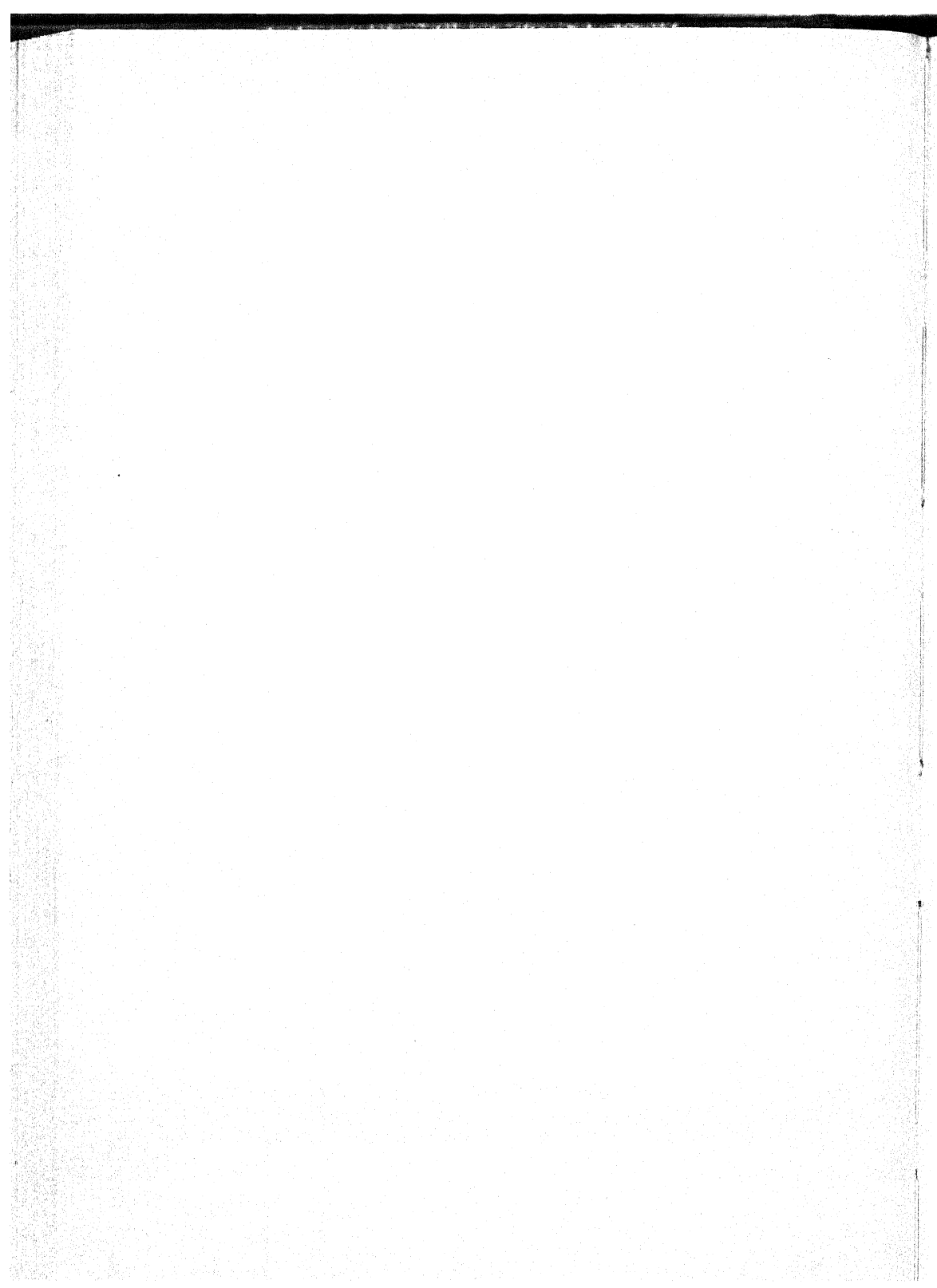
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Chapter VII: AGRICULTURAL EDUCATION

[Because each chapter covers a different subject and therefore will be used chiefly by a different constituency, it seems desirable to make each one complete and self-contained. For this reason, among others, a complete table of chapter contents is placed at the beginning of each chapter, rather than at the front of the volume. A list of all literature cited in the chapter will be found at the end of the chapter and the numbers in parentheses in the text refer the reader to the corresponding entries in this list. All entry numbers occurring in each major section of a chapter are also listed in numerical sequence at the end of that section, thus forming what is in effect a section list of literature cited. These features all should prove of great convenience to readers.]

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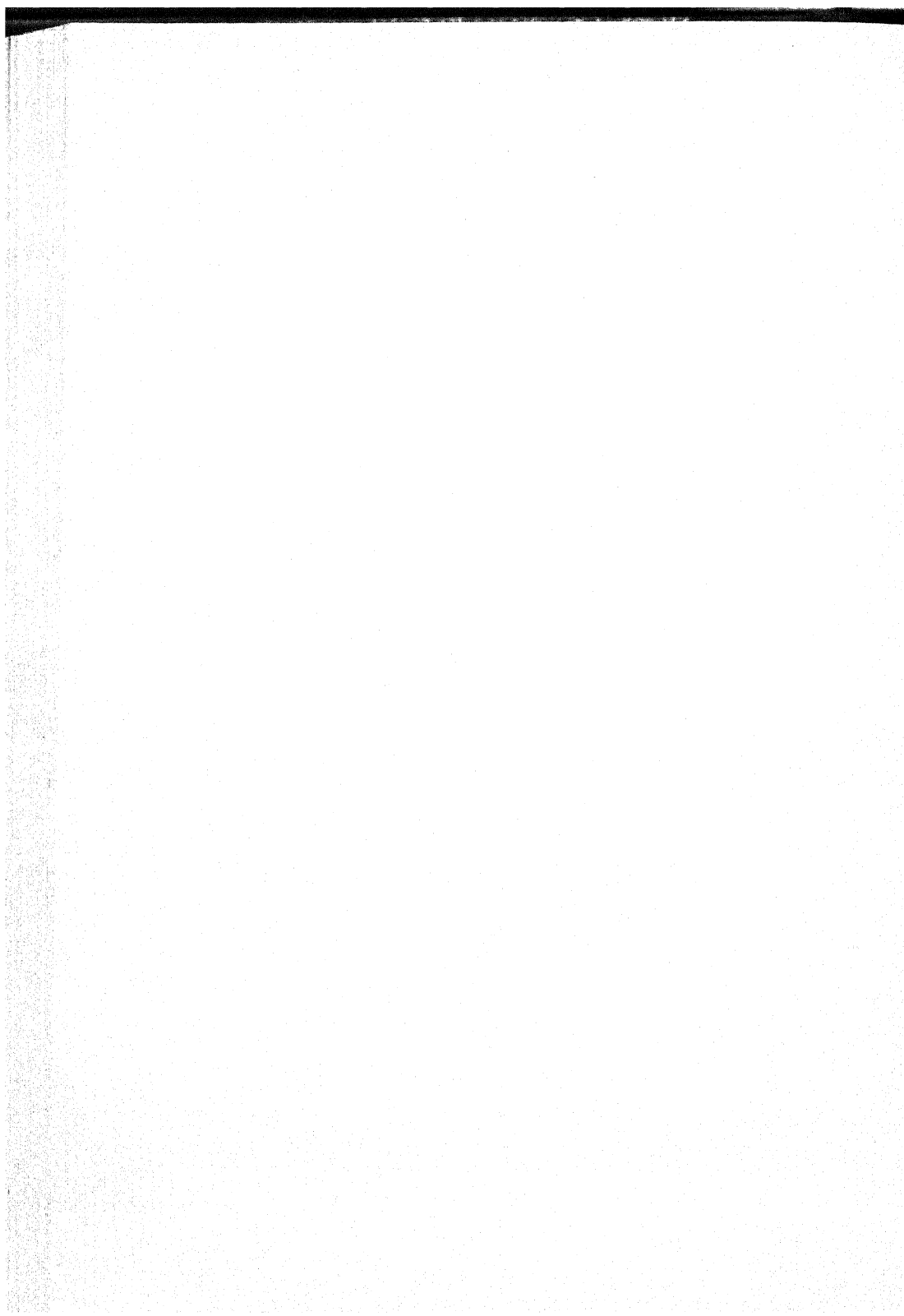
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Chapter VII

AGRICULTURAL EDUCATION

1. INTRODUCTION

BEFORE PROCEEDING to a discussion of agricultural education, it is well to make clear the definition and scope of the subject and to point out one of the governmental principles involved in education in America.

DEFINITION AND SCOPE

Agricultural education is used here in the broadest sense, to cover all those activities which commonly are referred to as resident teaching, experimentation and research, extension by demonstration, and also extension by the various information services, such as news services, radio services, lantern slide series, motion pictures, and exhibits of all kinds.

As in other chapters, the presentation is restricted to those activities in which there have been, or still are, official relations of some degree or kind. A much larger volume of detailed activity in which there is little need or opportunity for such relations must go unnoticed here. In no field covered by this volume on agriculture, however, have these relations been more profoundly fundamental to the development of our agricultural structure. Likewise, in no field have they been more fully and frequently discussed by official groups, or their history (33; 34; 35; 36)* more fully set forth by one who had a long and intimate connection with their development. Likewise, again, the laws relating to the development of the various institutions and activities in this field have been carefully compiled (9:143-62; 20:223-42; 24; 46-251; 89). It will be understood that no attempt is made to cite all the publications which cover any given phase of coöperative relations. Those which are cited usually represent either the most comprehensive treatments or papers exactly covering the particular item under discussion.

*Numbers in parentheses refer to the Literature Cited, at the end of the chapter.

FEDERAL LAND GRANTS FOR GENERAL EDUCATION

The principle of granting lands from the public domain for the support of schools was established at the beginning of our national existence. The Continental Congress, by ordinance of 1785, provided that section 16 in each township should be reserved for the maintenance of public schools within the township. In 1787 a further ordinance provided that this grant of one thirty-sixth of each township be perpetual and also provided that not to exceed two full townships be granted perpetually "for the purposes of a university." In 1803 the Congress made the State rather than the township the trustee for these reserved lands. In the Oregon Territory Act of 1848 the grant for public school purposes was increased to one-eighteenth of the township, represented by sections 16 and 36, and so continued. Later, three States, Arizona, New Mexico, and Utah, in the semiarid parts of the Union, were granted four sections or one-ninth of each township (24; 88—1930, No. 8). While these grants were not directly for agricultural education, they primarily were for the support of rural schools.

By 1929 these grants for the common schools of the several States had reached the enormous total of more than 98,500,000 acres, or an area equal to California and larger than Montana. The grants of two townships, more or less, in each State for the support of a university, with other grants for seminaries, academies, and normal schools had reached the large total of almost 4,000,000 acres in 1929. By 1929, again, the grants for special technical schools (mines, military), and schools for delinquents and defectives, totaled more than 3,173,000 acres. By 1928, the grants for the colleges of agriculture and the mechanic arts, discussed below, had reached the large total of 7,830,000 acres. For all four groups of educational purposes, these land grants have reached the grand total of 113,500,000 acres, or an area two-thirds as large as Texas.

2. RESIDENT TEACHING

THE LONG STRUGGLE to encourage and provide vocational training in agriculture and the mechanic arts is recorded first in two preliminary papers (33; 34), and later in an extensive and comprehensive publication of the Federal Department of Agriculture

(36). No more thrilling epic embodying the history of a single field of endeavor has ever been written. While we are concerned here primarily with the colleges of agriculture and the mechanic arts, or Land-Grant colleges, as they are called, and the more recent vocational education and civilian rehabilitation, there are some antecedent official actions which require mention. Much of the summarized information given here is derived from the two publications mentioned.

COLLEGES OF AGRICULTURE AND MECHANIC ARTS

These colleges are an outgrowth of three generations of discussion and experiment before the Civil War. A few of them were in existence before the war opened. Legislation to create such a system of vocational colleges was introduced in Congress before the Civil War but was opposed by many members from the Southern States. After their withdrawal, following the outbreak of the war, the legislation known as the (First) Morrill Act or Land-Grant College Act, was passed. The present national system is the direct result of this act of July 2, 1862, granting to each accepting State certain lands from the public domain for the purpose of establishing a college to give vocational education in the agricultural and mechanical industries.

Collectively, they are known as land-grant colleges, although individually they usually were named the State College of Agriculture and Mechanic Arts. Their curriculums now are characterized by courses in agriculture and all its foundation sciences, in most fields of engineering, including special agricultural engineering, and in veterinary science and home economics. In many States they are one of the colleges of the State university, but in some twenty or more States they are independent institutions. This independent status resulted from real prejudice against the movement on the part of the leaders of higher classical education, and a well-founded fear by their promoters that the infant vocational college would be handicapped by inclusion in the existing State university. In some States, the name has been changed officially in recent years to State College, as distinct from State University. In a few States where these independent institutions are established, they are included with the university and other institutions of higher learning under a single "Chancellor."

Federal Acts Providing Support

The antecedent attempts at legislation already have been mentioned. Beginning with the original act of 1862, three separate acts of Congress have subsidized the land-grant colleges in their resident teaching functions, in addition to the subsidies for research and extension, discussed later. These three acts (9; 20; 24; 46—251; 67; 88—1930, No. 8) are briefly discussed below.

The Morrill or Land-Grant College Act.—The land-grant feature of the Morrill Act is found in the following quotation :

That there be granted to the several States, for the purposes hereinafter mentioned, an amount of public land, to be apportioned to each State a quantity equal to thirty thousand acres for each Senator and Representative in Congress to which the States are respectively entitled by the apportionment under the census of eighteen hundred and sixty; Provided, That no mineral lands shall be selected or purchased under the provisions of this act.

Where sufficient public domain was lacking within a given State, land scrip was issued instead, the same to be sold and the purchaser to locate his land in the more abundant public lands of another State.

The announced purpose of the land grants was the endowment, support, and maintenance of at least one college where the leading object shall be, without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts, in such manner as the legislature of the States may respectively prescribe, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life.

In addition, Sec. 5 provided, in Condition 1, that the annual interest should be applied, without diminution, to the purposes named in Sec. 4, above,

except that a sum, not exceeding ten per centum upon the amount received by any State under the provisions of this act, may be expended for the purchase of lands or sites for experimental farms whenever authorized by the respective legislatures and States.

It was further required that the moneys derived from land or scrip sales should be invested in Federal, State, or other safe securities, and the legislatures were required to engage that such securities would yield not less than 5 per centum per annum on par

value, the capital amount to remain forever undiminished and the interest to be applied to the purposes of the act. None of the money might be expended for buildings. The States accepting the benefits of the act were obligated to assume the cost of administering the granted land and resulting funds, and the cost of land for the college site (except for experimental purposes) and of buildings. An annual report of the operations of the college, and any experimental farm attached thereto, was required to be made to the Secretary of the Interior and to each of the other land-grant colleges, while the governor of each accepting State was required to report to Congress on the sales of land and scrip. Later amendments extended the time within which States might take advantage of the provisions of the act.

The Second Morrill Act.—The act of 1890 (Second Morrill Act), for the further endowment of land-grant colleges, provided a fund of \$15,000 to each State for the fiscal year 1890, with annual increase of \$1000 per year for ten years thereafter, making a total of \$25,000 per annum in and after 1900, "for the more complete endowment and maintenance of colleges for the benefit of agriculture and the mechanic arts."

The statute provided that the money was to be applied only to instruction in agriculture, the mechanic arts, the English language, and the various branches of mathematical, physical, natural, and economic science, with special reference to their application in the industries of life, and to the facilities for such instruction.

A provision of the act forbade the payment of funds to any State where distinction of race or color was made in the admission of students, unless separate schools were established and an equitable distribution of the funds made between the two.

The funds were paid by the Secretary of the Treasury on certification by the Secretary of the Interior. The institutional treasurers were required to report to the Secretary of Agriculture and the Secretary of the Interior annually on the receipt of these moneys and their disbursement. The president of the college was required to report annually also "to the Secretary of Agriculture as well as the Secretary of the Interior regarding the condition and progress of each college," including any experiment station attached thereto. The Secretary of the Interior was "charged with

the proper administration of this law," and authorized to withhold funds from States not complying with its provisions.

The Nelson Amendment.—The Nelson Amendment of 1907 provided "for the more complete endowment and maintenance of agricultural colleges" by appropriating \$5000 to each State and territory for the fiscal year 1908, with an annual increase of \$5000 per year for the next four years, making a total of \$25,000 additional by the fiscal year 1912, and annually thereafter. This provided a grand total of \$50,000 annually to each State under the provisions of these two appropriating acts. The requirements with respect to reporting on the finances and on the condition and progress of the colleges remained the same.

Federal-State Coöperation

In addition to the coöperative acts of the General Land Office of the Interior Department in making the land grants available to the respective States and Territories, numerous other relations have developed. Some have been mandatory under the laws but more have been entirely voluntary. In their early years, the land-grant colleges had no organization of their own. A meeting of representatives of these institutions was called by the Federal Commissioner of Agriculture in July, 1885, to consider proposed legislation for Federal financing of a series of State agricultural experiment stations. Several committees were created, including an executive committee. The Hatch Act, creating these stations, became law on March 2, 1887. The many problems foreseen in the interpretation and administration of this law made a national organization very desirable. Accordingly, the executive committee previously mentioned called a meeting of representatives of the colleges and stations, which was held in Washington, D. C., in October, 1887. At this meeting, the Association of American Agricultural Colleges and Experiment Stations was organized and a constitution adopted. In 1920 the name was changed to Association of Land-Grant Colleges, and in 1926 to Association of Land-Grant Colleges and Universities.

Coöperation through the U. S. Department of Agriculture.—On October 1, 1888, the Commissioner of Agriculture established the Office of Experiment Stations to represent his Department in its

official and legal contacts with and responsibilities to the State experiment stations. In 1889, the Association elected the newly created Office of the Department to membership, with a voting delegate. While, officially, it was concerned only with the stations and not with resident teaching in the agricultural colleges, it yet had a large influence on the latter in three different ways. The first was through an assembling of information, documents, and photographs from the colleges for a national exhibit at the Paris Exposition of 1889. This, with a coöperative exhibit by the Office and the State colleges and stations at the World's Columbian Exposition in Chicago, in 1893, gave these institutions a sense of unity and importance in a national plan.

The second coöperative service rendered by the new Federal agency to the land-grant colleges was in acting as a clearinghouse for information for and about them. The proceedings of the annual convention of the Association of American Agricultural Colleges and Experiment Stations, for the first twenty-three years, 1887 to 1909, inclusive, and varying from some one hundred to two hundred pages each, were published by the Department of Agriculture. The proceedings of the first, or organizing, convention of October, 1887, never were published in full but are represented, in some measure, by the published *Report of the Committee on Station Work* (50—45; 53). The second convention, for 1888, actually was held on January 1—3, 1889, and the third was held in November of the same year. The proceedings of the second, third, and fourth annual conventions appeared in the three *Miscellaneous Bulletins* of the Office of Experiment Stations (65). Those for the fifth to the twenty-third conventions, covering the years 1891 to 1909, inclusive, appeared in the *Bulletin* series of the Office (64—7, 16, 20, 24, 30, 41, 49, 65, 76, 99, 115, 123, 142, 153, 164, 184, 196, 212, and 228). Thereafter they were published privately by the Association (2).

The constitution of the Association also was published by the Office of Experiment Stations (66—36). Organization lists showing the agricultural staffs of the colleges and stations were published annually until 1912 by the Office in its *Circular* (66—20) and *Bulletin* series (64—5, 12, 13, 19, 23, 27, 39, 47, 59, 74, 88, 111, 122, 137, 151, 161, 176, 197, 206, 224, 233, 247, and 253) and later

in one or another of the series of publications of the Department (47—4, 17, 34, 58, and 87; 48—12, 43, 67, 100, 134, 154, and 299).

Annual statistics of the land-grant colleges, as well as of the experiment stations, were compiled for 1894 and 1896 and issued in the *Circular* series (66—27 and 35) of the Office of Experiment Stations. Similar statistics were published annually by the Office from 1897 to 1902 in its series of *Bulletins* (64—51, 64, 78, 97, 114, and 128) and for the years 1903 to 1912 inclusive, in its *Annual Reports* (63). For the years 1904 and 1905, these data were published in the *Circular* series also (66—61 and 64). Thereafter, this work was done by the Office (then Bureau) of Education of the Interior Department (88), as noted later in this section.

One of the serious difficulties in tracing the place of publication of these annual compilations of information is the frequent change of publication title. While some change is necessary as activities expand and organization limits shift, a much nearer approach to uniformity of title easily might have been made. Three or four changes in a ten-year period were not uncommon.

The institutions themselves coöperated, of course, by furnishing records of personnel changes each year, and also the statistics which the Department compiled.

The third activity in which the Federal Office of Experiment Stations was helpful to the colleges of agriculture had to do more directly with resident teaching. In the annual visit made to each station by administrative officers of the Federal Office, beginning in 1894, for the purpose of the required inspection of projects and finances, there was much discussion of the teaching and research relations of the staff. Because of the personality and judgment of the Federal officers, they were freely consulted about educational matters, and their familiarity with all the institutions made them able to be helpful. It is probable that their influence on resident teaching in this period of transition and readjustment was far greater than their numbers and official relations would have indicated. In addition, the Office published the reports of the Association Committee on Methods of Teaching Agriculture, from 1897 to 1901 (inclusive), in its series of *Circulars* (66—32, 37, 39, 41, and 45). Other publications, also, in this field were issued from time to time in the *Circular* series (66—83, 97, 106, and 115). All

of the annual reports of this committee were included in the *Proceedings* (64) of the annual conventions of the Land-Grant College Association, published by the Office from 1891 to 1909, inclusive.

In a few cases there was actual coöperation in teaching. In one of a series of bulletins (*Bulletin* No. 46) issued by the Storrs (Connecticut) Agricultural Experiment Station and containing results of studies on cheese making in coöperation with the Dairy Division of the Federal Bureau of Animal Industry, the Station Director, in his Letter of Introduction, says:

"The Connecticut Agricultural College offers a course in cheese making during the winter term, this instruction being given by the experts of the United States Department of Agriculture located at Storrs."

After the creation of the Weather Bureau in the U. S. Department of Agriculture in 1891, members of its staff gave courses in meteorology in various institutions in order to interest men and to train them. For many years "Professor" was the official title of the principal men in the Bureau. At the present time, a Federal employee stationed on coöperative research at an agricultural college is allowed to teach an occasional course in his specialty. Likewise, in the educational courses conducted by the U. S. Department of Agriculture since 1922, some of them for graduate credit, faculty members from nearby universities are utilized occasionally as instructors.

More recently, coöperation has developed in providing advanced instruction for extension workers. Beginning with Wisconsin in 1929, summer courses for extension workers have been offered at the University of Wisconsin, Cornell University, and the Oregon and Utah Agricultural Colleges. Federal extension workers have acted as instructors in most of these institutions in some of these years. Courses have been provided for home-demonstration agents as well as for county agents (79—1932).

Coöperation through the U. S. Department of the Interior.—It will be recalled that the original Morrill Act of 1862 required that an annual report of each of the land-grant colleges be made to the Secretary of the Interior. The second Morrill Act, of 1890, provided that such an annual report be made to the Secretary of Agriculture as well as to the Secretary of the Interior. These reports

include finances and also the condition and progress of the college.

Annual statistical reports: The Office of Education in the Department of the Interior is the unit charged since 1913 with supervisory functions over the land-grant colleges and with assembling their statistics. The statistical matter is assembled in the present Division of Colleges and Professional Schools (formerly Division of Higher Education), in the Office of Education. It prepares an annual bulletin of some hundred pages, under the general title, *Land-Grant Colleges and Universities*, in which important facts are given by text, tabulation, and graph regarding the finances, equipment, facilities, curriculums, students, and graduates of these institutions, including those for negroes. Some comparative data from other institutions are included.

For the fiscal years 1913 to 1916, inclusive, these statistical data were published in Volume 2 of the *Annual Report* of the Commissioner (87). Beginning with 1917 they have appeared in the *Bulletin* series, which are numbered separately for each year (88).

Land-grant college surveys: The Bureau (now office) of Education has compiled and published the results of two different surveys of the land-grant colleges. The first comprised a description and interpretation of education as given in these institutions in the period from 1910 to 1920. The results were published in five parts in 1924 and 1925. The parts dealt with History and educational objectives, Liberal arts and sciences, Agriculture, Engineering and mechanic arts, and Home economics (88—1924, Nos. 33 and 37, and 1925, Nos. 4, 5, and 29).

At the request of the Executive Committee of the Association of Land-Grant Colleges and Universities, the Office of Education of the Department of the Interior entered upon a comprehensive special survey of these land-grant institutions, in 1927. An appropriation of \$117,000 was made by Congress to the Office in 1927 for this specific purpose. The land-grant institutions coöperated first in the filling of questionnaires by means of which the survey data were assembled and, secondly, by releasing no fewer than sixty-eight of their staff members at different times for special service in digesting, interpreting, and preparing the reports on different phases of the survey results.

This study undoubtedly was one of the most comprehensive

ever undertaken in the field of higher education. The purpose, as indicated by the Association, was to evaluate the accomplishments, the present status, and the future objectives of the sixty-nine land-grant institutions of the United States. The material collected in the course of the survey totaled approximately 500,000 pages of questionnaire returns, covering the major phases of the activities of these institutions. Included in these data were returns from more than 37,000 alumni and former students, and individual schedules for more than 12,000 members of the staffs.

The results were published in 1930 in two large volumes (25), totaling more than 1900 pages and covering material classified under nineteen different heads:

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| 1. Control and administrative organization | 10. Home economics |
| 2. Business management and finance | 11. Arts and sciences |
| 3. Work of the registrar | 12. Commerce and business |
| 4. Alumni and former students | 13. Teacher training |
| 5. Student relations and welfare | 14. Military education |
| 6. Staff | 15. Professional veterinary medicine |
| 7. Library | 16. Summer session |
| 8. Agriculture | 17. Extension services |
| 9. Engineering | 18. Research work |
| | 19. Graduate work |

Of these nineteen parts of the survey (each of which was issued separately as well as in the volumes), No. 8, Agriculture, No. 13, Teacher Training, and No. 15, Professional Veterinary Medicine, are pertinent to this section on resident teaching in agriculture. Nos. 17, Extension Services, and 18, Research Work, are pertinent to later sections of this chapter on Agricultural Education.

The publications listed in the Literature Cited at the end of this chapter which have been cited in the section entitled "Introduction" and in the subsection on Agricultural Colleges in the section on Resident Teaching are Nos. 2, 9, 20, 24, 25, 33, 34, 35, 36, 46, 47, 48, 50, 53, 62, 63, 64, 65, 66, 67, 87, 88, and 89.

SECONDARY VOCATIONAL EDUCATION

The demand for secondary vocational training in the mechanic arts developed early in the last century. The movement for similar training in agriculture is much more recent, having first become effective about forty-five years ago (36:322-82). It was stimulated

by the subsidies for higher vocational education in the land-grant colleges of agriculture and the mechanic arts, provided by the successive acts of 1862, 1890, and 1907. It was stimulated also by the acts of 1887 and 1906, creating and financing State agricultural experiment stations. The increasingly complicated economic conditions accompanying the growing mechanization of both agriculture and industry were large factors in the growth of the demand.

The development of vocational agriculture in secondary schools may best be presented by tracing the history and accomplishments of four successive institutional influences. The first is the series of agricultural schools located in the several States. The second is the Office of Experiment Stations of the U. S. Department of Agriculture. The third is the Bureau of Education of the Department of the Interior, and the fourth is the Federal Board for Vocational Education, created in 1917 and merged with the Office of Education of the Department of the Interior in 1933.

Secondary Agricultural Schools

Almost coincidently with the establishing of the Federal-State system of agricultural experiment stations in 1887, the States began establishing secondary schools of agriculture. In some States these were county schools, in others they were congressional district schools, in one they were allotted to judicial districts, while in the larger number they were distributed in areas of indeterminate size without regard to political subdivisions.

The movement began in Alabama, which, by a legislative act of 1889, set out to establish agricultural schools and experiment stations in the nine congressional districts of that State, the last five being authorized in 1895 (64—220). About 1906, Georgia adopted the same plan and had equipped all her eleven congressional districts by 1912. Wisconsin began the development of county agricultural schools in 1901, and was followed by Michigan (64—242). In the quarter century after Alabama set the example, there was a large development of the agricultural school idea throughout the country. Those States which made the county the unit of area were Maryland, Michigan, Mississippi, North Carolina, North Dakota, and Wisconsin. Those establishing schools in each congressional district were Alabama and Georgia. The Superior Court judicial

district was the basis of location in Oklahoma. The indeterminate area, disregarding political units, was adopted in this period by Arkansas, California, Colorado, Massachusetts, Minnesota, Nebraska, New York, Pennsylvania, and Vermont (64—250).

The location and development of these various schools involved considerable intrastate coöperation. The major State agencies, besides the legislature and the governor, were the State Departments of Agriculture and Education, the State College of Agriculture, and its agricultural experiment station. In some States the counties or other local official agencies helped to provide the location, including an experiment farm.

After the movement for county and district agricultural schools had developed in various States, agricultural subjects began to be added very rapidly to the curriculums of ordinary high schools. In the two years beginning with 1910 the total number of institutions giving courses in agriculture was more than trebled, the rate of increase being about 2.5 per day. The rapid progress of this movement crystallized sentiment in favor of a national program of secondary vocational education, and facilitated the passage of the Smith-Hughes Vocational Education Act and the creation of the Federal Board for Vocational Education.

There was relatively little active Federal-State coöperation in this field. The Soil Survey Division of the Federal Bureau of Soils collaborated in determining soil types and values on the experiment farms, usually of 200 to 300 acres, attached to the congressional district agricultural schools in Alabama and Georgia in 1906 and 1907. The Section of Agricultural Instruction of the Office of Experiment Stations rendered considerable assistance to the movement. Indirectly it aided by assembling and publishing a vast amount of information on secondary education in agriculture. Directly, it coöperated in some studies and in the publication of others. Both series of coöperative services are discussed in the next subsection.

Office of Experiment Stations

The Office of Experiment Stations of the U. S. Department of Agriculture, established in 1888, had coöperated very closely from the beginning with the Association of American Colleges and Ex-

periment Stations. As early as 1897 the Office began to publish in its *Circular* series (66—32, 37, 39, 41, and 45) the annual reports of the Association's Committee on Teaching Agriculture. In 1906 the Office established a Section of Agricultural Instruction, while as early as 1902 it had begun the publication of papers dealing with materials and methods of teaching agriculture in secondary schools, including some addresses on these subjects by Federal officials. Several of these were published between 1902 and 1913 in the *Circular* series of the Office (66—49, 52, 60, 77, 90, 91, 100, and 118). Others were issued in its *Bulletin* series (64—139, 186, 204, 220, 242, 250, and 255) from 1903 to 1913, inclusive, or in the *Year-books* of the Department (52—1912:471-82).

One of these bulletins (64—204), discussing phases of agricultural teaching in English rural schools and in London, was prepared in coöperation with the Bureau of Plant Industry, and another (64—255), discussing educational contests in agriculture and home economics, was prepared by the Director of Agricultural Extension in Indiana.

After the Office of Experiment Stations *Bulletin* and *Circular* series were discontinued in 1913, several other similar papers appeared in the series of Department *Bulletins* (43—7, 132, 213, 281, 294, 305, 346, 385, 392, 521, 527, 540, 592, 646, 653, 763, and 784) in the years from 1913 to 1919. Of these, one contained data furnished by the Colleges themselves (43—7), one was prepared by the University of Missouri in coöperation with the Department (43—540), and a third (43—763) acknowledged assistance from the Dairy Division and the Office of Home Economics. Several publications in still another series (46—33, 67, 68, 69, 155, 156, 157, 158, and 159) informed teachers of agriculture how they might facilitate classroom instruction by using certain farmers' bulletins on different agricultural subjects, which had been issued by the U. S. Department of Agriculture.

With the creation of a Section of Agricultural Instruction by the Office of Experiment Stations in 1906, the Office began to take a wider interest in the promotion of secondary education in agriculture. Attention was given presently to the development of the agricultural schools in the various States. Between 1909 and 1912 it published a discussion of the Congressional district system as

organized in Alabama (64—220) and likewise a discussion of the county system as developed in Wisconsin (64—242), these being prepared by officers of those schools. It published also a discussion of the Arkansas district agricultural schools (64—250) written by one of its own staff. It also aided these special agricultural schools, and the series of high schools teaching agriculture, through making available to them the vast quantity of information contained in the series of publications previously listed.

Later, the Section of Agricultural Instruction, then in the States Relations Service, developed close coöperation with the Bureau of Education of the Department of the Interior in continuing studies of secondary agricultural education. A discussion of the district agricultural schools of Georgia, prepared by the staff of the Section, was published in 1916 by the Bureau of Education (88—1916, No. 44). During the fiscal year 1917 a detailed study of vocational agricultural instruction in high schools of six northeastern States was made under this coöperative agreement and the results submitted for publication by the Bureau in the following year (88—1918, No. 3). Through similar coöperation a survey was made of agricultural instruction in two counties of Texas and the results submitted to the Bureau for publication.

When the National Educational Association created a Commission on the Reorganization of Secondary Education, the Section of Agricultural Instruction was represented on this committee. Its report on secondary vocational agricultural instruction was prepared by the Committee on Agriculture and submitted to the Association in 1918. One such report was published by the Bureau of Education (88—1920, No. 35).

In coöperation with the Ohio State Department of Education and State College of Agriculture, a manual of agriculture for the elementary schools of Ohio was prepared in 1918 for publication by the State Department of Education. In 1917 a similar manual was prepared for Virginia and published in 1918 by its State Department of Education.

In coöperation with the Department of War a one-year general course in agriculture was prepared by the States Relations Service for use among soldiers. Series of lantern slides on special agricultural topics, each accompanied by a printed syllabus, were circu-

lated in coöperation with State Departments of Education, lesser educational units, and the Young Men's Christian Association service in the United States and France.

In 1919, in coöperation with the Federal Board for Vocational Education, preparation of a two-year course for negro vocational schools was begun. The first year covered crop production, and the second year concerned animal production.

Trends developing from 1915 onward served to modify and gradually to decrease the attention given to secondary education in agriculture by the Section of Agricultural Instruction. The passage of the Smith-Lever Act creating a Federal-State Agricultural Extension Service, effective July 1, 1914, made extension education the dominant phase of agricultural instruction fostered by the Department of Agriculture. The Bureau of Education of the Department of the Interior had begun to give increasing attention to agricultural education at all levels. The creation of the Federal Board for Vocational Education, effective on July 1, 1917, provided an organization definitely charged with promoting secondary agricultural education. The result of these combined influences was that after 1919 the Federal Section of Agricultural Education ceased to function very actively in the field of secondary agricultural education, except as it concerned extension practices. This is evidenced by its cessation of publication on the subject except for the previously mentioned series of *Department Circulars* describing the use of certain farmers' bulletins by agricultural teachers.

Bureau of Education, Interior Department

As early as 1908, the Bureau of Education began to publish bulletins relating to secondary agricultural education. The first one was authored by a professor in Cornell University College of Agriculture (36:333). From 1912 to 1919, during this period of transition and development, several more were issued, mostly prepared by the Bureau's own staff members. The collection and publication of statistics on agricultural education were among the services rendered by the Bureau. Its coöperation with other Federal agencies is discussed under each of those agencies.

The Federal Board for Vocational Education

The Smith-Hughes Act, creating the Federal Board for Vocational Education, was passed in 1917. The subject of secondary education in agriculture, home economics, trade, and industry had been before the Congress for some years, the movement having started as early as the beginning of the present century. The two ideas, agricultural extension and secondary agricultural instruction, were combined in several pieces of proposed legislation. When the Smith-Lever bill was introduced, attempts were made to include vocational teaching of trade, industry, and agriculture along with agricultural extension, but finally the former was dropped in order not to jeopardize the success of the latter. Happily, both labor, as represented by the American Federation of Labor and the National Society for the Promotion of Industrial Education, and industry, as represented by the Chamber of Commerce of the United States, were strongly and actively in favor of vocational training in agriculture and industry. In 1914, when the act providing for agricultural extension was passed, the Congress also created a Federal Commission on National Aid for Vocational Education. It made its study and report and successive bills were introduced.

The act of 1917 created the Board for Vocational Education to coöperate with the States in carrying out the purposes of the law (21). This Board was independent of Federal executive departments, although Section 6 of the act provided that the Secretaries of three Departments and the Commissioner of Education should be *ex officio* members. Early in 1933, the Board was transferred, by executive order, to the Office of Education of the Department of the Interior.

The Smith-Hughes Act.—The Smith-Hughes Act for vocational education (14—1:49-56; 46—151:155-62) was approved on February 23, 1917, and became effective as of the July 1 following. Its purpose is stated in its introductory words:

An Act to provide for the promotion of vocational education; to provide for coöperation with the States in the promotion of such education in agriculture and the trades and industries; to provide for coöperation with the States in the preparation of teachers of vocational subjects; and to appropriate money and regulate its expenditure.

(Section 1) That there is hereby annually appropriated, out of any money in



the Treasury not otherwise appropriated, the sums provided in sections two, three, and four of this Act, to be paid to the respective States for the purpose of cooperating with the States in paying the salaries of teachers, supervisors, and directors of agricultural subjects and teachers of trade, home economics and industrial subjects, and in the preparation of teachers of agricultural, trade, industrial, and home economic subjects; and the sum provided for in section seven for the use of the Federal Board for Vocational Education for the administration of this Act and for the purpose of making studies, investigations, and reports to aid in the organization and conduct of vocational education, which sums shall be expended as hereinafter provided.

Section 2 provided, for purposes of cooperation with the States in paying salaries of teachers, supervisors, or directors of agricultural subjects, an appropriation of \$500,000 for fiscal year 1918, with annual increase of \$250,000 for each of the next six years; one of \$500,000 for fiscal year 1925; and a total of \$3,000,000 for fiscal year 1926 and annually thereafter, the sums to be allotted to the States in the proportion which their rural population bore to the total rural population of the United States.

Section 3 provided equal funds in a similar way for cooperation in paying salaries of teachers of trade, home economics, and industrial subjects, the allotments to be on a basis of proportional urban population and not more than 20% of the funds to be applied to home-economics teachers.

Section 4 provided a fund increasing from \$500,000 in fiscal year 1918 to \$1,000,000 in 1921 and annually thereafter for the purpose of cooperation with the States in preparing teachers, supervisors, and directors of agricultural subjects, and teachers of trade, industrial, and home economics subjects, the sums to be allotted to the States in proportion of total population.

Section 5 provided that the States, to obtain the benefits of the act, should accept by legislative authority the provisions of the act, and designate or create a board of not less than three members having the necessary power to cooperate with the Federal Board for Vocational Education in administering the provisions of the act. Each of the three funds (sections 2, 3, and 4, above) could be accepted separately.

Section 6 provided:

That a Federal Board for Vocational Education is hereby created, to consist of the Secretary of Agriculture, the Secretary of Commerce, the Secretary

of Labor, the United States Commissioner of Education, and three citizens of the United States to be appointed by the President, by and with the advice and consent of the Senate. One of the said three citizens shall be a representative of the manufacturing and commercial interests, one a representative of the agricultural interests, and one a representative of labor . . .

The board shall have power to coöperate with State boards in carrying out the provisions of this Act. It shall be the duty of the Federal Board for Vocational Education to make, or cause to have made studies, investigations, and reports with particular reference to their use in aiding the States in the establishment of vocational schools and classes and in giving instruction in agriculture, trades and industries, commerce and commercial pursuits, and home economies. Such studies, investigations, and reports shall include agriculture and agricultural processes and requirements upon agricultural workers; . . . home management, domestic science, and the study of related facts and principles; and problems of administration of vocational schools and of courses of study and instruction in vocational subjects.

Section 6 further provided that the Board might coöperate, in its discretion, with the United States Department of Agriculture in its studies concerning agricultural education and with the United States Department of Labor and Commerce and the United States Office of Education in other studies. Some of the coöperative enterprises and their published results are mentioned at appropriate places in the text of this subsection.

Section 8 specified the duties required of the State Boards for Vocational Education as follows :

That in order to secure the benefits of the appropriation for any purpose specified in this Act, the State board shall prepare plans, showing the kinds of vocational education for which it is proposed that the appropriation shall be used; the kinds of schools and equipment; courses of study; methods of instruction; qualifications of teachers; and, in the case of agricultural subjects, the qualifications of supervisors or directors; plans for the training of teachers; and, in the case of agricultural subjects, plans for the supervision of agricultural education, as provided for in section ten. Such plans shall be submitted by the State board to the Federal Board for Vocational Education, and if the Federal Board finds the same to be in conformity with the provisions and purposes of this Act, the same shall be approved. The State board shall make an annual report, to the Federal Board for Vocational Education, on or before September first of each year, on the work done in the State and the receipts and expenditures of money under the provisions of this Act.

Section 9 conditioned the expenditure of each dollar of Federal funds for teachers, supervisors, and directors of the subjects named, or for the training of such teachers, supervisors, and directors, on

the expending of an equal amount by the State or local community, or both, for the same purposes. State or local agencies also were required to bear the cost of supplementary teaching necessary to a well-rounded course of training, and Sections 10 and 11 required also that State and local agencies should provide the plants and equipment needed for the work.

Section 14 required the Federal Board to ascertain if the several States were using the funds in accord with the law, and to certify such compliance to the Secretary of the Treasury as a prerequisite to further quarterly payments of the moneys. This provision is very similar to that in the Second Morrill Act of 1890, making appropriation to the States for maintenance of their land-grant colleges and universities, noted above. Section 16 permitted the Board to withhold funds from any State not complying with the law, and section 18 required an annual report to Congress by the Federal Board, such reports to contain the reports made by the State Boards (see section 8).

The George-Reed Act.—The George-Reed Act of February 5, 1929, enlarged the funds available for the three purposes of the original act by the sum of \$500,000 in fiscal year 1930, and increased the total by an additional \$500,000 for each year thereafter for four years, thus reaching a total of \$2,500,000 in 1934. One half of this fund was to be allotted to the States, on the basis of proportion of their farm population to total farm population in the United States, for the agricultural teaching and supervision previously authorized. The other half was to be allotted to States on the basis of proportion of their rural population to total rural population, and to be used for promoting training in home economics. Both halves were subject otherwise to all the restrictions of the original act (14—151:164—65). This legislation seems to have been caused by the fact that the original act provided for home economics training in connection with industrial training in the city but not in connection with agricultural training in the rural districts.

Coöperative Activities.—The coöperative relationships include Federal and State and local agencies, and the two separate functions of the training of teachers of vocational education and the giving of the vocational education itself. The resulting activities

include relations in the fields of planning, supervision, and statistical service, as well as in financing.

Official Agencies: Numerous official agencies are involved in this nation-wide work of secondary vocational education. The Federal agency is the Federal Board for Vocational Education, which was an independent agency from its creation in 1916 until the administrative reorganization of portions of the Federal structure early in 1933 when it was made a part of the Office of Education in the Interior Department. Within each State is a State Board for Vocational Education, which may be an agency created expressly for that purpose or a previously existing educational board designated to act in that additional capacity. In California, for example, the State Board of Education was designated to function as the State Board for Vocational Education. Then there are the tertiary schools, or colleges and universities, which train the teachers for service in vocational education in the secondary schools. The former include such official institutions as the State university, agricultural college, normal schools or teachers' colleges, and others where training for teaching agriculture, trade and industrial subjects, and home economics can be had. In 1932 there were 178 such institutions, varying in number from one to nine in each of the different States and Territories. Of these, 89 gave training to teachers of agriculture, and 108 to teachers of home economics. Finally, there are the secondary schools themselves, in which vocational education in the three fields is given. In 1932 they numbered 8818 in agriculture and 4268 in home economics.

Planning and Supervision: Under the law, as presented previously, the State Board for Vocational Education is charged with formulating the State program, including minimum standards. This program then is submitted to the Federal Board for Vocational Education and becomes operative under Federal aid only when approved by this Board. After the State program has been approved, it is the further duty of the Federal Board to see that its minimum requirements as to the nature, quality, and duration of the teaching of vocational subjects, and of the training of the teachers themselves, are met in all the projects receiving Federal aid. Annually, the Federal Board certifies to the Secretary of the Treasury that the several States and Territories have met the re-

quirements, and are eligible to receive their allotments of the Federal fund. The State plans are subject to review and reapproval every five years.

The State Board for Vocational Education selects the schools which shall receive Federal aid, selects the personnel to whom payments shall be made for salary, and selects the institutions of higher learning in which training of teachers for the three fields of vocational education shall be conducted. The State Board also supervises all activities within the State and, as noted above, makes a full report of procedure and progress annually to the Federal Board. The Federal Board exercises the supervision required by law by means of a study of the annual reports submitted by the State Board and by personal inspection of the teaching and teacher training done within the State, through visits of its traveling representative.

Financial Relations: The chief purpose of the Federal Act was to stimulate rather than to subsidize. It was expected, therefore, that State, county, and local funds would greatly exceed the Federal funds when the work had got well under way. In fact, progress in that direction might well be regarded as a criterion of the successful operation of the act in any State, and as a justification for its application to the country as a whole. This act, like several others of the so-called Federal subsidizing acts, provides for the expenditure of only such Federal funds as are matched dollar for dollar by State or local funds. In some quarters the belief has been held that State and local agencies will raise only such funds for any particular activity as will enable them to obtain the Federal contribution available for that purpose. Because of this iterated belief, it is interesting to note the statistics of State and local expenditures for such coöperatively subsidized and conducted activities as vocational education, agricultural research, and agricultural extension, discussed in this chapter, and forest-fire prevention and highway construction, discussed elsewhere in this series of volumes.

For the teaching of vocational agriculture and home economics, and for the training of teachers in those subjects, the required matching of total Federal funds offered has been equalled or somewhat exceeded by State appropriations since the passage of the

act. In addition, the local funds contributed for teaching these two subjects have grown from small sums in the beginning to amounts nearly doubling the State contributions in 1932. Because the teacher-training institutions are not local but State agencies, the local funds are employed in teacher training to a relatively smaller extent.

In 1932, the funds provided for vocational education and teacher training in the three different fields amounted to a grand total of \$33,400,000. Of this sum, Federal funds totaled \$8,400,000, State funds amounted to \$9,000,000, and local funds reached the enormous sum of \$16,000,000. Of the grand total stated, \$11,000,000, or one third, went for teaching and teacher training in vocational agriculture. Of this sum the Federal contribution was approximately \$4,000,000. In the same year, \$6,000,000 were expended for teaching and teacher training in home economics, of which total the Federal contribution was \$1,480,000, or less than one fourth. For California alone, the total Federal and State funds for all the purposes of the act are exactly equal and the local funds are nearly three times as great as the Federal or State funds and therefore nearly half again as large as Federal and State funds combined. These facts show a very healthy public sentiment concerning the value of these activities, especially in the third year of severe depression.

The passage of the George-Reed Act made large additional appropriations available in the fiscal year 1930 and thereafter, and thereby increased the Federal contributions and the matching State funds. Local funds made an immediate proportional increase in 1931 and 1932. Although these were depression years, the number of persons needing vocational education and having time to devote to it was greatly increased.

Research Relationships: One of the major duties of the Federal Board for Vocational Education, as stated in Section 6 of the Smith-Hughes Act, is "to make or cause to have made studies, investigations, and reports with particular reference to their use in aiding the States . . ." This requirement, and the comparative novelty of the procedure and subject matter for vocational training, has made the Board one of the chief research and publishing agencies of the Federal government, during the past fifteen years.

In addition to the presentation of facts, both textual and tabular, in the usually large annual reports (13) the Federal board has published more than 150 bulletins (14) in its fifteen years of existence, not to mention a few so-called *Miscellaneous Circulars* (15). Some of the bulletins explain the administrative procedure necessary in connection with the various educational activities conducted. Others assemble and present the best experience of all the States, or of selected groups of States or communities, in some one activity. Still others present statistical data on results obtained in the several activities which the Board promotes.

In this way, the results obtained in any phase of vocational teaching, or training of teachers, as tabulated by the individual States, in any or all States, are made available for the use of State boards, teachers, and teacher-trainers in all the other States. This is a service of great value, which the individual State could perform for itself only with great difficulty and at great cost. It should be noted also that this research and publishing service is rendered wholly without cost to the States so far as their allotment of Federal funds is concerned.

There is much occasional coöperation between various agencies which is not required by the legislative acts. In preparing the subject matter of the courses in agriculture and home economics, and in meeting problems of agricultural readjustment the Federal and State boards of vocational education have worked in close coöperation with extension workers and other specialists of the U. S. Department of Agriculture and the State colleges of agriculture. There has been coöperation also with the Federal Farm Board (now merged with Farm Credit Administration) in matters pertaining to teaching the orderly marketing of farm products. Certain commercial agencies, such as railroad and broadcasting corporations, coöperate with these official agencies in promoting the program of vocational education. In its own technical field the Federal Board for Vocational Education has coöperated extensively with the corresponding boards of individual States or groups of States in surveys or other types of investigation. Similarly, the boards may receive coöperation from private companies that are interested in the better vocational training of their prospective personnel.

Coöperative results: The results obtained under the coöperative procedure discussed above, may be measured by a study of the statistics published by the State and Federal boards. These statistics cover the number of institutions, teachers, and pupils in teacher training and vocational education in the three different fields of agriculture, trade and industry, and home economics. In addition, the data show the different types of schools, all-day, part-time, and evening, the all-day predominating; the division of teachers and pupils by sex; the amounts of money expended for the different types of activity; and the sources of those moneys, whether Federal, State, or local.

In 1932, there were 8818 Federally aided schools teaching vocational agriculture, and 4268 in home economics. These schools had 8001 teachers in agriculture and 6449 teachers in home economics. In that year 252,199 pupils received instruction in agriculture in Federally aided schools, and 265,495 in home economics. These figures show that one-fourth of the total number of pupils were in each of the two subjects named and the other half were in the trade and industrial schools. In the teacher-training schools there were 200 teachers and 3171 students in agriculture and 323 teachers and 6252 students in home economics, in 1932, out of a total of 851 teachers and 22,468 pupils in teacher training.

The publications listed in the Literature Cited at the end of this chapter which have been cited in this subsection on Secondary Vocational Education in the section on Resident Teaching are Nos. 13, 14, 15, 21, 36, 46, 52, 64, and 66.

CIVILIAN REHABILITATION TRAINING

The rehabilitation of persons disabled in warfare or in industrial accidents, or as the result of illness, and the training of persons defective at birth, calls for resident teaching of still another kind than that, already discussed, which is given in colleges or in the secondary vocational schools. Rehabilitation, moreover, as a Federal-State coöperative activity, is of more recent origin than either of the other activities.

History of Rehabilitation Activities

Among the studies conducted by the Federal Board for Vocational Education in 1917 and thereafter were several on the vocational

reëducation and placement of men disabled in military and naval services. As the World War progressed, this matter became increasingly important and numerous organizations were concerned with it. After much informal discussion a conference was called which included representatives of all Federal and private organizations directly or indirectly concerned with the problem. This conference, through a subcommittee, drafted a proposed bill providing for rehabilitation under a commission representing five different Federal agencies, including the Federal Board for Vocational Education. The resulting act, however, when approved on June 27, 1918, placed the work under the Federal Board for Vocational Education.

Action by the board was made dependent on previous determination of personal eligibility by the Bureau of War Risk Insurance. The great burden placed on the latter by demobilization slowed down the work, and the divided responsibility caused so much complaint that finally a requested amendment to the act placed responsibility for determining eligibility on the Federal Board for Vocational Education. Even so, the enormous size of the problem caused continued complaint and finally an investigation by Congress, which recommended combining all the work of this kind in the Bureau of War Risk Insurance. No legislation was passed, however, and complaint continued to increase, resulting in an investigation by the House Committee on Education of the 66th Congress, in the spring of 1920. This Committee's report (41) favored combining all the work under one unit, which resulted later in the Act of August 9, 1921, creating the Veterans' Bureau and relieving the Board for Vocational Education of its functions in the rehabilitation of disabled veterans.

At that time the Rehabilitation Division of the Board had some 6000 employees, and there were nearly 90,000 men in training in some 3000 schools and colleges. What number of these were prepared for entry into agricultural pursuits is not now ascertainable.

During the early discussion of vocational rehabilitation for disabled veterans, suggestions were made for a similar work to benefit persons injured in industry. These suggestions were developed partly in Congress and partly in the States. One section of the proposed bill for veteran rehabilitation provided for civilian re-

habilitation also, but it was dropped in order not to compromise the passage of relief legislation for veterans. It soon reappeared, however, as a separate bill which became law on June 2, 1920, nearly a year before Congress removed from the Board for Vocational Education the work of rehabilitating disabled service men.

Civilian Rehabilitation Act

The Civilian Rehabilitation Act of June 2, 1920 (U. S. Stat. L, 41, 735) was modeled very closely after the Vocational Education (Smith-Hughes) Act of 1917 and the administration of the work was placed with the Federal Board for Vocational Education. The purpose as stated in Section 1, was . . . "to provide for the promotion of vocational rehabilitation of persons disabled in industry or in any legitimate occupation and their return to civil employment . . ."

Section 2 gave a gratifyingly wide interpretation to the phrase "persons disabled," in the following language :

That for the purpose of this Act the term "persons disabled" shall be construed to mean any person who, by reason of a physical defect or infirmity, whether congenital or acquired by accident, injury, or disease, is, or may be expected to be totally or partially incapacitated for remunerative occupation ; the term "rehabilitation" shall be construed to mean the rendering of a person disabled fit to engage in a remunerative occupation.

The public sentiment which lay behind the legislation for rehabilitation education, for service men and civilians alike, was primarily humanitarian or philanthropic. The intent was to relieve human suffering caused by being deprived of the means of earning a livelihood. Later there has developed an increasing sentiment in favor of such training as an economic measure also, designed to reduce the number of those permanently unemployed. Both are splendid motives. The very nature of the activities, however, places the subject primarily in the field of public welfare, rather than in the field of education. Brief discussion of it is warranted here only by its relation to education in agriculture.

Coöperative Relationships

The major coöperative requirements affecting the relations of the Federal Board and the several State Boards of Vocational Education are essentially the same in the Civilian Rehabilitation Act as they were in the Vocational Education Act of three years earlier.

The State Board makes plans for the rehabilitation program, subject to approval by the Federal Board, which also does enough supervising to insure that the States are complying with the law and therefore are eligible to receive succeeding annual allotments of the Federal fund on certification by the Board to the Secretary of the Treasury. As under the earlier law, this supervision is carried out by the examination and study of the annual reports made by the State Boards, supplemented by visits of agents of the Federal Board.

The law specifically requires two reports from the State boards. One contains plans showing (a) the kinds of vocational rehabilitation and schemes of placement for which it is proposed that the Federal and State matching funds shall be used; (b) the plan of administration and supervision; (c) the courses of study proposed; (d) the methods of instruction; (e) qualifications of teachers, supervisors, directors, and other administrative officers and employees; and (f) plans for the training of teachers, supervisors, and directors. The other report contains an account of the work done in the State each year, and of the receipts and expenditures of moneys made available under the provisions of the act. The State boards are required to cooperate with any other State agency concerned with the administration of any State workmen's accident or liability laws.

By section 6 of the act the Federal Board for Vocational Education was authorized and subsidized for the purpose of making studies, investigations, and reports in regard to the vocational rehabilitation of disabled persons and their placement in suitable gainful occupations. As in the case of vocational education, a large volume of research is conducted on the methods, effectiveness, and results of rehabilitation. The results of this research are published by the Board in its *Bulletins* (14), *Opportunity Monographs* (16), and *Rehabilitation Monographs* (17). This work is essentially a service to the States, as these results are primarily for the use of State and local agencies.

The Federal Board for Vocational Education has many relations with other official and private organizations besides the State boards. Among those with which it works in carrying out the purposes of the act in administration or research are the International

Association of Industrial Accident Boards and Commissions, the U. S. Employees' Compensation Commission, the National Safety Council, the National Society for Vocational Education, various casualty insurance companies, and numerous industrial establishments. It also conducts national or regional conferences with State rehabilitation officials, occasionally conducts regional training courses for their workers, and, under the Federal law, coöperates with the State boards in the manner discussed.

Within the States, the Federal law requires that the State boards shall coöperate with any State Workmen's Compensation, Industrial Accident, or Industrial Liability Commission. There also is widespread voluntary coöperation between the State board and other State and municipal officials, and with trades unions, fraternal and commercial organizations, social agencies, and individuals.

Financial relations.—The allotment of funds under the Civilian Rehabilitation Act is in the proportion of the total State population to that of the nation. The most significant difference in the financing of this activity, as compared with other acts embodying Federal-State matching of funds and coöperative administration, has been the temporary periods for which appropriations have been assured. The original act of June 2, 1920, provided appropriations for four years only. In 1924, the Congress extended the duration of the Act for a six-year period, 1925–30, but failed to make an appropriation, so that for a half year no Federal funds were available. By act of June 9, 1930, the Congress renewed the duration of the act for another three years, 1931–33. On June 30, 1932, the duration of the act was again extended for a four-year period, 1934–37.

Naturally, the periodic uncertainty whether the act would be renewed, and the actual failure to appropriate any funds for half of one year, have slowed down if not actually disrupted State and local plans for coöperation in rehabilitation. It is difficult if not impossible to plan wisely and surely for a growing program of work if coöperation by the Federal agency is temporary and its renewal unsure. The Federal fund appropriated for the fiscal year 1921 was \$750,000 and that for each succeeding year (except 1925) was \$1,000,000. Owing probably to the novelty of the enterprise and to the continued uncertainty of Federal participation, the

State matching of the Federal funds increased rather slowly and called for the entire amount for the first time in the fiscal year 1932. Only forty-four of the States have yet elected to take advantage of the law.

Results of the coöperative activities.—On June 30, 1929, there were 16,823 persons registered for rehabilitation training. A year later there were 20,412, and by June 30, 1932, the number had risen rapidly to 27,403. It is evident that the growth in the nine years to June, 1929, was relatively slow, and that the effects of the advancing depression are seen in the increase. These figures do not include many thousands who are rehabilitated by the State departments of education, independently of the coöperative work of the Federal-State plan.

More than 4500 persons were rehabilitated in 1930, and 5550 in 1932. It should be remembered that rehabilitation is reported only for those who actually are placed in positions. This large number was placed while depression conditions increased the difficulty of finding jobs. Commercial coöperation in placement is increasing. The average cost of rehabilitation of an individual person is less than \$300 from all sources, which is less than the average cost of maintaining the same person in idleness for a single year. The rehabilitated workers enter more than six hundred different occupations, ranging from unskilled labor to the highly technical professions. It is impossible to determine the number who enter activities in or closely related to agriculture. It will be remembered that more than one-fourth of the pupils in vocational education were in agriculture. The proportion of rehabilitated persons entering agriculture, horticulture, poultry raising, dairying, bee keeping, etc., is very much smaller than one-fourth.

California is one of the ten highest States in point of numbers registered for rehabilitation training. The total on June 30, 1932, was 1125 persons. During the year 241 had been rehabilitated. Federal funds amounting to \$64,000 were available, and State and local funds reached the larger total of \$83,000.

3. AGRICULTURAL EXPERIMENTATION AND RESEARCH

THE IMPROVEMENT of agricultural products and practices through experimentation is not new in this country. It was promoted by the

British government in the American colonies at various times and places. The young republic was guided by men, like Washington and Jefferson, who believed in agricultural science and promoted it wholeheartedly. The founding of the Philadelphia Agricultural Society and the Charleston Agricultural Society in 1785 was chiefly for the purpose of ascertaining and disseminating information obtained by their members through experiment, observation, and reading. These and other regional agricultural societies, the local farmers' clubs which developed rapidly in the early decades of the last century, and the State agricultural societies and State departments of agriculture which were widely established somewhat later, all had agricultural experiments and the publications of results in mind. As pointed out earlier in this chapter, in the discussion of the development of resident teaching in agriculture, the promoters of a Federal agricultural agency, who were active from the time of Washington onward, held investigation to be a primary function of such an agency. It was only natural, therefore, that provision for experiment should have been made when Federal action finally was taken.

The Organic Act of May 15, 1862, creating the U. S. Department of Agriculture, provided for obtaining agricultural information through the conduct and interpretation of "practical and scientific experiments." In the Land-Grant College Act (first Morrill Act) of July 2, 1862, Condition 1 of Section 5 permitted not to exceed 10 per cent of the interest received from the land-grant funds in any State to be expended for the purchase of lands for experimental farms, if authorized by the State legislature. In neither of these acts was any mention made of coöperation with the other agencies, nor of any coördination of their investigational activities in any way.

STATE AGRICULTURAL EXPERIMENT STATIONS

With the impetus given by the Land-Grant College Act, and from other sources, the States began the creation of agricultural experiment stations as early as 1875. There were eighteen such stations in operation by July 1, 1887, when the Hatch Act, providing for a system of State experiment stations with Federal financial aid, became effective. Of these eighteen stations, eleven had been organized with the help of the land-grant fund interest authorized in the

Land-Grant College Act, whereas seven were independent State stations (3; 36:200). In the meantime, successive conventions of agricultural college leaders (50—22; 51—2 and 9) called by the Commissioner of Agriculture to be held in Washington in 1882, 1883, and 1885, resulted in extensive discussion of experimental methods and results. A committee on coöperative experiments was formed in 1882 and the U. S. Department of Agriculture was asked to summarize European experiments, to plan and promote coöperative experiments in this country, and to ask for Federal aid for experimentation (36:201-2).

As a result of these meetings and the continuing discussions, several bills were introduced in Congress, from 1882 onward, with the intent to create and subsidize a system of experiment stations to be located in the several States. At first these were planned to be in the nature of local branches of the Federal Department of Agriculture, but gradually the idea was developed of a series of stations under State responsibility and control, with some degree of Federal supervision and coördination (36:200-208). It is interesting to note that the idea of coöperation between two or more State stations, and between the various States and the Federal Department, was strongly present from the first. In fact, five years of experiments with fertilizers, coöperative between the stations of nine States, were reported at the meeting of agricultural leaders in 1882 (36:201).

Federal Legislation for Stations

Following the agitation just discussed, there was passed the Hatch Act, establishing and subsidizing a system of State agricultural experiment stations, effective on July 1, 1887. This was followed in 1906 by the Adams Act, doubling the annual Federal contribution and increasing Federal responsibility. Finally the Purnell Act, in 1925, provided gradually a large increase in the Federal funds for research, especially in the newly developing fields of agricultural economics, home economics, and rural sociology. These acts were so new in their attitude to relations, so fundamental in their nature, and so far reaching in their effects on our agricultural structure and on Federal-State relations, that quotation and discussion of each of the three seem amply justified.

Hatch Act, establishing stations.—A committee appointed by the agricultural convention of 1885 coöperated with the Commissioner of Agriculture in promoting experiment-station legislation. Representative William H. Hatch of Missouri introduced a bill in January of 1886 which, in a modified form passed by the Senate, was accepted by the House and became law on March 2, 1887, and effective on July 1 of that year. The main portions of the bill are given below (9:147-49; 20:234-37; 46—251:17-18; 64—1:58-68; 67:89):

AN ACT To establish agricultural experiment stations in connection with the colleges established in the several States under the provisions of an act approved July second, eighteen hundred and sixty-two, and of the acts supplementary thereto.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That in order to aid in acquiring and diffusing among the people of the United States useful and practical information on subjects connected with agriculture, and to promote scientific investigation and experiment respecting the principles and applications of agricultural science, there shall be established under direction of the college or colleges or agricultural departments of colleges in each State or Territory . . . a department to be known and designated as an "agricultural experiment station" . . .

Section 2. That it shall be the object and duty of said experiment stations to conduct original researches or verify experiments on the physiology of plants and animals; the diseases to which they are severally subject, with the remedies for the same; the chemical composition of useful plants at their different stages of growth; the comparative advantages of rotative cropping as pursued under the varying series of crops; the capacity of new plants or trees for acclimation; the analysis of soils and water; the chemical compositions of manures, natural or artificial, with experiments designed to test the comparative effects on crops of different kinds; the adaptation and value of grasses and forage plants; the composition and digestibility of the different kinds of food for domestic animals; the scientific and economic questions involved in the production of butter and cheese; and such other researches or experiments bearing directly on the agricultural industry of the United States as may in each case be deemed advisable, having due regard to the varying conditions and needs of the respective States and Territories.

Section 3. That in order to secure, as far as practicable, uniformity of methods and results in the work of said stations, it shall be the duty of the United States Commissioner [now Secretary] of Agriculture to furnish forms, as far as practicable, for the tabulation of results of investigation or experiment; to indicate from time to time such lines of inquiry as to him shall seem most important, and, in general, to furnish such advice and assistance as will best pro-

mote the purpose of this act. It shall be the duty of each of said stations annually, on or before the first day of February, to make to the governor of the State or Territory in which it is located a full and detailed report of its operations, including a statement of receipts and expenditures, a copy of which report shall be sent to each of said stations, to the said Commissioner of Agriculture, and to the Secretary of the Treasury of the United States.

Section 4. That bulletins or reports of progress shall be published at said stations at least once in three months, one copy of which shall be sent to each newspaper in the States or Territories in which they are respectively located, and to such individuals actually engaged in farming as may request the same and as far as the means of the station will permit. Such bulletins or reports and the annual reports of said stations shall be transmitted in the mails of the United States free of charge for postage, under such regulations as the Postmaster General may from time to time prescribe.

Section 5. That for the purpose of paying the necessary expenses of conducting investigations and experiments and printing and distributing the results as hereinbefore prescribed, the sum of fifteen thousand dollars per annum is hereby appropriated to each State, to be specially provided for by Congress in the appropriations from year to year, and to each Territory...

The essential features of the above-quoted sections are the establishment of a system of State-controlled agricultural experiment stations, with their general scope outlined; a requirement that they report in detail annually their operations and finances to the governor, to the Secretaries of Agriculture and Treasury, and to each of the other stations; an obligation on the station to publish and distribute bulletins, said bulletins and reports to be transmitted in the mails free of postage charges; and an annual Federal appropriation of \$15,000 to each State, without requirement of State matching funds.

Other portions of the act provided that, from the first annual appropriation not to exceed one-fifth, and from each succeeding annual appropriation not to exceed 5 per cent, might be expended on buildings to be used for the purposes named; that the assent of the legislature (or the governor) was prerequisite to payment of the moneys; and that the Federal Government was not bound to continue the payments.

Adams Act, enlarging subsidies.—As early as 1902, the Association of American Agricultural Colleges and Experiment Stations began a movement to increase the Federal contributions for experiment station research. This movement finally culminated in the

passage of the Adams Act on March 16, 1906. Because of the many new features, as compared with the Hatch Act of 1887, it seems desirable to quote a portion of the text, and to summarize the new provisions (20:238-40; 46-251:19-20). The act not only doubled the Federal appropriation to each State, but also restricted the use of the new fund to "original researches or experiments." The new provisions were:

- (a) Gradual increase in the annual appropriation from \$15,000 to \$30,000;
- (b) the specification that the money shall be used only for conducting original researches or experiments bearing directly on the agricultural industry;
- (c) that if the money be diminished, lost, or misapplied it must be replaced by the receiving State, and that no further payment should be made to such State until the fund was so replaced;
- (d) that an annual report of receipts and expenditures by each station be made to the Secretary of Agriculture on schedules prescribed by him;
- (e) that funds should be paid to the States only on certification by the Secretary of Agriculture to the Secretary of the Treasury, after ascertaining compliance with the law;
- (f) that if the Secretary of Agriculture withheld certification from any State he should report the fact to the President and that the State might appeal to Congress from the decisions of the Secretary;
- (g) that not to exceed 5 per cent might be used either for buildings or in purchase or rental of land;
- (h) that the Secretary of Agriculture is charged with the proper administration of the law, and with making an annual report to Congress on the receipts, expenditures, and work of the stations.

(Section 1) Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That there shall be, and hereby is, annually appropriated . . . to each State and Territory, for the more complete endowment and maintenance of agricultural experiment stations now established or which may hereafter be established in accordance with the act of Congress approved March second, eighteen hundred and eighty-seven, the sum of five thousand dollars in addition to the sum named in said act for the year ending June 13th, 1906, and an annual increase of the amount of such appropriation thereafter for five years by an additional sum of \$2000 over the preceding year and the annual amount to be paid thereafter to each State or Territory shall be \$30,000 to be applied only to paying the necessary expenses of conducting original researches or experiments bearing directly on the agricultural industry of the United States, having due regard to the varying conditions and needs of the respective States or Territories.

Section 3. That if any portion of the moneys received by the designated officer of any State or Territory . . . shall by any action or contingency be di-

minished or lost or be misapplied, it shall be replaced by said State or Territory to which it belongs, and until so replaced no subsequent appropriation shall be apportioned or paid to such State or Territory; . . .

Section 4. That on or before the first day of July in each year after the passage of this act the Secretary of Agriculture shall ascertain and certify to the Secretary of the Treasury as to each State and Territory whether it is complying with the provisions of this act and is entitled to receive its share of the annual appropriation for agricultural experiment stations under this act and the amount which thereupon each is entitled, respectively, to receive. If the Secretary of Agriculture shall withhold a certificate from any State or Territory of its appropriation, the facts and reasons therefor shall be reported to the President, and the amount involved shall be kept separate in the Treasury until the close of the next Congress, in order that the State or Territory may, if it shall so desire, appeal to Congress from the determination of the Secretary of Agriculture. If the next Congress shall not direct such sum to be paid, it shall be covered into the Treasury; and the Secretary of Agriculture is hereby charged with the proper administration of this law.

Section 5. That the Secretary of Agriculture shall make an annual report to Congress on the receipts and expenditures and work of the agricultural experiment stations in all the States and Territories, and also whether the appropriation of any State or Territory has been withheld, and if so, the reason therefor.

Section 6. That Congress may at any time amend, suspend, or repeal any or all of the provisions of this act.

Purnell Act, enlarging scope and funds.—The two decades following the passage of the Adams Act in 1906 saw an enormous increase in the scope and activities of American agriculture and therefore a corresponding increase in the demands made upon the agricultural experiment stations. The total annual Federal contribution to the State stations had risen to \$1,440,000 in 1911 and remained stationary thereafter. In the meantime, State appropriations for these institutions had grown enormously, as had their receipts from fees, sales, and miscellaneous sources.

In 1925 the total income of the agricultural experiment stations in forty-eight States had reached the enormous sum of about \$10,500,000, of which \$1,440,000 was from Federal sources and approximately \$9,000,000 was from State sources. Of the latter, approximately \$6,000,000 was derived from State appropriations, about \$1,500,000 was derived from sales, and about \$500,000 from fees. The other million was derived from balances from the previous year and from miscellaneous sources.

In view of the large increase in State contributions, as compared with the Federal funds, the Land-Grant College Association and the U. S. Department of Agriculture again collaborated in promoting further action by Congress. The result was the Purnell Act of February 24, 1925, discussed below (46—251:20-21) :

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That for the more complete endowment and maintenance of agricultural experiment stations now established, or which may hereafter be established, in accordance with the act of Congress approved March 2, 1887, there is hereby authorized to be appropriated, in addition to the amounts now received by such agricultural experiment stations, the sum of \$20,000 for the fiscal year ending June 30, 1926; \$30,000 for the fiscal year ending June 30, 1927; \$40,000 for the fiscal year ending June 30, 1928; \$50,000 for the fiscal year ending June 30, 1929; \$60,000 for the fiscal year ending June 30, 1930; and \$60,000 for each fiscal year thereafter, to be paid to each State and Territory; and the Secretary of Agriculture shall include the additional sums above authorized to be appropriated in the annual estimates of the Department of Agriculture, or in a separate estimate, as he may deem best. The funds appropriated pursuant to this act shall be applied only to paying the necessary expenses of conducting investigations or making experiments bearing directly on the production, manufacture, preparation, use, distribution, and marketing of agricultural products and including such scientific researches as have for their purpose the establishment and maintenance of a permanent and efficient agricultural industry, and such economic and sociological investigations as have for their purpose the development and improvement of the rural home and rural life, and for printing and disseminating the results of said researches.

The other provisions of this act are essentially those of the Adams Act. In further definition of the Secretary's authority and responsibility, the annual agricultural appropriation act for more than thirty years has carried this clause in connection with the appropriation of the Federal grants :

The Secretary of Agriculture shall prescribe the form of the annual financial statement required under the above acts, ascertain whether the expenditures are in accordance with their provisions, coordinate the work of the Department of Agriculture with that of the State agricultural colleges and experiment stations in the lines authorized in said acts, and make report thereon to Congress.

Beginning with the fiscal year 1930, each State received for its experiment station, or stations, Federal funds totalling \$90,000, from the Hatch, Adams, and Purnell Acts. Two-thirds of this total amount came from the latter Act. In 1931, about 48 per cent of the

Purnell Act funds were expended by the States for projects in agricultural economics, home economics, and rural sociology, fields of research which the funds were especially designed to cover.

Federal Supervision of State Stations

The Secretary of Agriculture was given certain advisory authority over the State agricultural experiment stations by the original Hatch Act of 1887. A new unit, called the Office of Experiment Stations (9; 11; 52—1897:135-43; 94:149-53; 95:57-60), was set up in the Department in 1887 to administer the Hatch Act. To it was committed also the administration of the more specific later acts. The Office sponsored several early publications discussing the history and objectives of the Stations and other pertinent data concerning them (3; 37; 38; 39; 64—1, 26, and 80). In 1893, the Secretary recommended that Congress give to the Department of Agriculture additional direction of the disbursement of Federal funds to the State stations. In 1904 the Congress provided (U. S. Stat. L. 28:264, 271) that the Secretary should inspect the stations, determine the nature of their work and expenditures, and prescribe the form of their annual financial statement (9:57-59). In the Adams Act of 1906 and the Parnell Act of 1925, the Secretary is specifically charged with the proper administration of the law.

This Federal administration comprises two rather distinct phases, namely, the examination and approval of lines of work to be carried wholly or in part on either the Adams or the Purnell funds, and, secondly, the auditing or verification of the annual fiscal report of the station, which must be made on forms prescribed and furnished by the Secretary of Agriculture.

The language of the Hatch Act, the original legislation establishing the stations, is not so restrictive of the nature of the experiments for which the funds may be expended, and, therefore, submittal of projects to be supported from this fund and their approval before they are entered upon, is not required by the Department.

The Adams Fund, according to the wording of the act, is permitted

to be applied only to paying the necessary expenses of conducting original

researches or experiments bearing directly on the agricultural industry of the United States.

The Purnell Fund, as specified in the act, shall be applied only to paying the necessary expenses of conducting investigations or making experiments bearing directly on the production, manufacture, preparation, use, distribution and marketing of agricultural products and including such scientific researches as have for their purpose the establishment and maintenance of a permanent and efficient agricultural industry; and such economic and sociological investigations as have for their purpose the development and improvement of the rural home and rural life, and for printing and disseminating the results of said researches.

The restrictive wording of these acts, as quoted above, regarding the objects to which the funds provided may be applied, indicates that the first obligation of the Secretary of Agriculture is to require the submission of projects for his approval in advance of beginning work upon them if they are to be supported wholly or in part from these funds. In actual operation, a new project must be submitted in advance and, after study and approval by the Department of Agriculture, may be begun by the station. In addition, the Department, toward the close of each fiscal year, asks each station for a program covering the experimental work to be conducted during the ensuing fiscal year in each of the projects which previously have been approved for support under either of these funds.

Obviously, the requirement on the Department to approve projects before their initiation places a corresponding obligation upon the experiment station to outline these projects so clearly, and to define their scope and extent so accurately, that the Department may be enabled to determine if they meet the requirements of the law. The plan of operation, under these mutual requirements, has worked very successfully, and only infrequently have cases arisen where a project desired by a station could not be formulated with sufficient clearness to obtain approval from the Secretary of Agriculture.

The second legal obligation of the Department of Agriculture in the administration of these several acts is to require an annual statement of receipts and expenditures, on forms prescribed and furnished by the Department. This statement is then audited with

care to determine that all the expenditures have been for purposes authorized by the acts providing the funds.

An annual examination of the accounts under these Federal funds is made and the station work is reviewed to correlate the expenditures with the stations' activities. Special attention is given to the projects approved under the Adams and Purnell Funds to obtain assurance that the efforts put forth on each individual project warrant the expenditures for salaries and maintenance for which vouchers are submitted in evidence. Assurance is further sought that all items of expenditure are appropriate under the interpretation, by the Secretary of Agriculture, of the Adams and Purnell Acts under which the funds are granted.

After the close of the fiscal year the Department receives from the experiment stations the financial reports on schedules prescribed by the Secretary of Agriculture and furnished by the Department. These schedules provide for a separate account on each of the three funds in question. These reports are examined by the Office of Experiment Stations with respect to their correctness and with reference to recommendation for approval by the Secretary of Agriculture. On the basis of the information gathered, the Secretary certifies the experiment stations to the Treasury Department to receive the allotments of the Federal funds as they become due. While the Hatch Act is not so explicit upon this point, the Adams and Purnell Acts both state that the quarterly payments shall be made by the Secretary of the Treasury upon the warrant of the Secretary of Agriculture.

A representative of the Office of Experiment Stations visits each of the stations at least once during the year for personal examination of its work and expenditures. This involves not only the examination of accounts, but also consultations with the director of the station and the leaders of the various projects; discussions of matters of administration, policy, and personnel; inquiries into facilities for research; consideration of programs of work; and, finally, the preparation of a report on each station.

To indicate the scope of the supervision which must be exercised by the Office of Experiment Stations, it is necessary only to observe that the station projects in operation on June 30, 1930, numbered 7672. Of these, 458 were Adams Act projects and 1336 were Pur-

nell projects, both series requiring extensive Federal-State contacts and Federal supervision. These projects constituted nearly one-fourth of the total number. In the same year the total annual income of the experiment stations in the forty-eight States was more than \$17,000,000, of which something more than \$4,300,000, or one-fourth of the total, was from Federal sources. With the financial curtailment caused by the depression, there has been some reduction in total revenues and in total projects, but as yet no reduction in the direct Federal contributions. The reduction in projects has been due to completion of some without starting new ones, to consolidation of some in the interests of efficiency, and to the actual discontinuation of some unfinished projects because of reduced appropriations by the State or by Congress to coöperating Federal agencies. The Adams Act projects have decreased by 22 in this two-year period, but Purnell Act projects increased by 122 in the same period.

FEDERAL STATIONS, OFFICES, AND LABORATORIES

Besides large facilities in the District of Columbia, the United States Department of Agriculture maintains experiment farms, field stations, field offices, and field laboratories widely distributed throughout the nation. Some of those immediately inside or outside of the boundaries of the District are merely physically separate laboratories of the Federal Bureaus in Washington. All of the great number elsewhere are true field stations of the Department. In size they vary from national forests covering all or parts of several counties, through game refuges, to small plots of land used for limited breeding or plant-protection experiments. The field offices vary likewise from a regional or district headquarters occupying an ample suite of rooms with a large staff of administrative, clerical, and technical employees (such as the regional headquarters or regional experiment stations of the Forest Service), to a single office room in a commercial or Federal building, or to a private house in which one room serves as office and laboratory. In scope of activities both the offices and the stations vary from the extremely wide range of activities supervised by a regional headquarters of the Forest Service, through the extensive experimentation of a combined crop and livestock experiment farm, to a study

of the control of a single insect pest or fungus disease on a single crop in a single district.

The best picture of the location, size, nature, and scope of these outlying units of the Department may be had from the little bulletin, *Directory of Field Activities*, published at intervals by each of the Federal Bureaus having extensive work and organization in the field, and usually containing a map showing the location of each unit. These agencies comprise the Bureaus of Agricultural Economics (56); Animal Industry (60: forty successive issues, 1910 to 1933); Biological Survey (48—49); Entomology (47—80; 48—83); Plant Industry (48—1, 64, and 129); Plant Quarantine and Control Administration (48—47 and 155); and the Forest Service (80).

A picture for the Department as a whole is given in the annual publication entitled *List of Technical Workers in the Department of Agriculture and Outline of Department Functions*. This has been published in several different series of Department publications. Beginning with 1927 it has been issued as a *Miscellaneous Publication* (48—5, 32, 63, 93, and 123). Under each Bureau is shown, by its subject-matter divisions, the location and personnel of all field stations (48—233, 304).

If these field activities are not coöperative with any State agency or other Federal agency they do not enter into this study. If they are coöperative, the relations are discussed in the appropriate subject-matter chapters. A general history of their development and a discussion of the principles governing their location and operation are all that need be presented here.

Field Stations

Most of the coöperative investigations of the Federal bureaus are conducted at the State agricultural experiment stations, or at sub-stations, sometimes called branch stations. In addition, however, some of the bureaus have field stations or experiment farms established quite independently of the State agencies. Some of these stations, or some of the projects conducted on them, have been made coöperative with the States in recent years, while others still remain independent stations or projects. Other new field stations were established by concerted plan and action of Federal and

State agencies, and thus were coöperative from the start. Some of the independent stations were established by the Department in order to conduct needed investigations. Others were desired by local communities, which wished either to solve perplexing problems or to be equal to other communities that had obtained such stations. Local chambers of commerce or other organizations have enlisted the interest of the district's representative in Congress and obtained Federal appropriations for the establishment and maintenance of a station. Some of the stations thus provided through local initiative have been very helpful to the Department program, and have supplemented the State program. Others have not been really needed, and by their absorption of subsidies actually have prevented more worthy projects from getting support.

Only three Bureaus of the Federal Department of Agriculture, namely, Plant Industry, Animal Industry, and Chemistry and Soils, maintain any considerable number of agricultural field stations. Plant Industry has by far the largest number. Its Divisions of Cereal Crops and Diseases, Cotton and Other Tropical Plants, Dry-Land Agriculture, Forage Crops and Diseases, Foreign Plant Introduction, Horticultural Crops and Diseases, Sugar Plants, Tobacco and Plant Nutrition, and Western Irrigation Agriculture, all have field stations. Those of the last-named unit are all located on the reclamation projects of the Bureau of Reclamation of the Department of the Interior. The field stations of the Bureau of Animal Industry are confined largely to its Division of Animal Husbandry.

In the Bureau of Plant Industry (48—1, 64, and 129), the Division of Cereal Crops and Diseases has conducted its field investigations in coöperation with the States from the first, and has had but two independent stations, a dry-land cereal station in Texas and a rice station in California. The former was discontinued about 1920, and the latter made coöperative with the State in 1923. Cotton and Other Tropical Plants has been essentially a noncoöperative organization so far as relations with the State stations are concerned. It has a few independent stations on which there is informal coöperation by other Federal units. Dry-Land Agriculture has about a dozen independent stations in the Great Plains Area, from Texas to North Dakota and Montana. These are con-

cerned with crop rotations and tillage methods with reference to moisture conservation, and therefore constitute a series of specialized stations. At other points its work is done on State branch stations. Foreign Plant Introduction has a series of five stations, known as Plant Introduction Gardens, at various strategic points in the United States. As these are concerned more with receiving material from abroad, growing it under expert supervision, and increasing it for distribution where it is found to be of probable value, these stations do not lend themselves to State coöperation as do most stations dealing with crop and livestock production. Horticultural Crops and Diseases has a few independent stations, mostly specialized, such as pecan, potato, and vineyard stations. Sugar Plants has a few independent stations. The field stations of Western Irrigation Agriculture, as previously noted, were established to solve the problems of the settlers on the reclamation projects of the Bureau of Reclamation. They cover both crop and livestock investigations. Some of the many stations of these Divisions which started as independent units have since become coöperative with other Federal units or with the experiment stations of the States in which they are located, or with both groups. More of them, doubtless, could do so profitably.

In the Bureau of Animal Industry (60) the Division of Animal Husbandry has gradually developed a few more or less independent experiment stations, such as the U. S. Morgan Horse Farm in Vermont (which now is used for general livestock), the Dubois Sheep Experiment Station in Idaho, the Range Livestock Experiment Station in Montana (on the site of a former Army post), and the Southwest Poultry Experiment Station in Arizona. A station for testing the effects of poisonous plants on different classes of livestock is maintained in one or another of the national forests, with some coöperation from the Forest Service. Both the Division of Animal Husbandry and the Division of Dairying, now the Bureau of Dairy Industry, have taken part in livestock investigation on the stations of the Divisions of Dry-Land Agriculture and Western Irrigation Agriculture of the Bureau of Plant Industry.

The Soil Erosion Stations are a recent development, caused by a recognition of the devastation being wrought by erosion throughout the country. They are being located in each of eighteen eroding

agricultural regions of the United States, with an undetermined additional number in eroding areas of more or less mountainous range and forest lands. Those in agricultural areas are in some measure coöperative with the States.

Field Offices and Laboratories

Federal field offices and field laboratories are maintained in large numbers by several Bureaus of the United States Department of Agriculture, and in smaller numbers by several others. The most important Bureaus in point of numbers of such outlying units are Animal Industry (60), Agricultural Economics (56), Biological Survey (48—49), Entomology (48—83), Food and Drug Administration, Plant Quarantine (48—47 and 155), Plant Industry (48—1, 64 and 129), and Weather, and the Forest Service (80). Those having fewer such units are Agricultural Engineering, Chemistry and Soils, Dairy Industry, and Public Roads. Of these various Bureaus, the work of the Biological Survey and the Forest Service belongs, for the most part, to the volume on Natural Resources, whereas that of the Food and Drug Administration and the Meat Inspection Division of the Bureau of Animal Industry, which comprises the largest series of field laboratories of that Bureau, belongs rather in the field of Public Health. The Bureau of Public Roads is in the field of Transportation.

The Bureau of Agricultural Economics has some two hundred field offices (56), serving its work in crop and livestock estimates, commodity inspection, market news services, etc. Many or most of these services are coöperative with State agencies. The Bureau of Agricultural Engineering has some thirty-five or forty field offices and laboratories interested in drainage, irrigation, soil-erosion, and farm-equipment studies, many of them in coöperation with State agencies. Animal Industry, besides its meat-inspection locations, maintains a very large number of field offices and laboratories to support the administration of eradication campaigns, livestock inspection, packers and stockyards control, meat inspection, etc. Many or most of these activities, except meat inspection, are coöperative with one or another of the State agencies. Incidental to the control of injurious rodents and predatory animals, the Bureau of Biological Survey maintains a few field offices and labora-

tories, which properly relate to agriculture. Chemistry and Soils maintains a few field laboratories, including a rather complete one at Los Angeles in fruit and vegetable chemistry. The Bureau of Dairy Industry has a few laboratories. Entomology has nearly a hundred field laboratories widely distributed over the country. Until recently, most of them have been noncoöperative. The Plant Quarantine Bureau maintains an extensive series of field offices or quarantine stations, especially along our coasts and the Mexican border. Many of these collaborate with State Departments of Agriculture and other agencies. The Bureau of Plant Industry has established many field offices and laboratories, mostly for research and administrative activities, throughout the country. The larger number of these are maintained in coöperation with State research and control agencies although there still are many noncoöperative activities. The Weather Bureau maintains more than two hundred field stations for gathering meteorological data, including its many State headquarters. By the very nature of its work, much of it cannot be coöperative, although coöperation is welcomed wherever obtainable.

FEDERAL-STATE COÖPERATION IN RESEARCH

Coöperation between Federal and State agencies in agricultural research may occur in connection with three different sets of institutions. In order of their importance to coöperative activities these three are: State stations, substations, and laboratories; Federal field stations and laboratories; and Federal facilities at the seat of government in the District of Columbia. By far the larger numbers of the coöperative projects, naturally, are undertaken at the State stations and substations, because these represent the most numerous and extensive facilities to be found in the areas where the problems needing investigation are encountered. Some discussions of the principles involved have been published (1; 4; 5).

Coöperation between Federal and State agencies in various publication services, on the other hand, results in the issuance of large numbers of collaborative publications from Federal sources and relatively fewer from State agencies. This is only natural. Much of the coöperative research is on problems of importance to several or many States and properly, therefore, the results are published

by the coördinating Federal agency. Publications summarizing data concerning the stations themselves can be compiled and published most effectively by the central agency. The same is true of journals open to the results of research from both State or Federal agencies, or given to abstracting the published research results for the convenient use of all agencies. On the other hand, the Federal agency publishes none of the results of independent State investigation except such as appear in the *Journal of Agricultural Research*.

Coöperative Research Projects in the States

Individual research projects may be coöperative between two or more State experiment stations or between one or more such stations and a Bureau or Bureaus of the U. S. Department of Agriculture. All important coöperative projects have been discussed in the various subject-matter chapters of this volume, such as those on Agricultural Economics, Animal Industries, Agricultural Chemistry, Plant Industries, Soils and Soil Management, etc. All that needs to be presented here is the statistical summary of these projects, and their financial support.

In recent years, the Office of Experiment Stations has reviewed all proposals made by the different Bureaus of the Department of Agriculture for research projects coöperative with the various States. These proposals are first submitted to the Director of Scientific Work of the Department and then passed on by the Office. A record of all coöperative projects, whether interstate or Federal-State likewise is kept by the Office (62).

In 1930, of the 7672 station projects in operation, 1169, or more than 15 per cent, were coöperative, either between stations or with the U. S. Department of Agriculture. This number represented a net increase of about 10 per cent over the previous year, caused largely by the final increment of funds from the Purnell Act. Nearly 100 coöperative projects were completed and approximately 200 new ones undertaken during the year. Among the total were some 21 major regional projects which involved the coöperation of from three to more than thirty different stations and included also from one to three Bureaus of the Department. Of the total number of active coöperative projects, 169, or about 14 per cent, received

support from Purnell Act funds, and 17, or about 2 per cent, from Adams Act funds. All of the State Experiment Stations took part in some coöperative enterprise. It is especially interesting to note that California led the list with 53 such coöperative projects. Her only near competitors were Washington and North Carolina, with 49 and 48, respectively.

Since 1930 there has been a marked decrease in the number of coöperative projects and presumably in total projects also. Coöperative enterprises decreased by 192, or 15.5 per cent, in 1931 and by 124, or 12.5 per cent, in 1932, leaving 863 in operation. The highest number for any State was 43, and at least one State had none remaining. These heavy decreases probably were caused most largely by decreases in the appropriations of the coöperating Federal agencies. The same causes were active during 1933 and doubtless produced further effects in the same direction.

The 1176 coöperative projects of 1930 and the 863 projects of 1932 were distributed by general subject matter, as indicated below. In the parentheses, the numbers of projects in 1930 are given first, followed by those remaining in 1932. Crop production, improvement, and protection, mostly coöperative with the Federal Bureau of Plant Industry (398 and 334); Agricultural economics and rural sociology, mostly with the Bureau of Agricultural Economics (311 and 143); Animal industries, including dairying and meat improvement, chiefly with Animal Industry and Dairy Industry (184 and 128); Chemistry, fertilizers, and soils, mainly with Chemistry and Soils (88 and 70); Entomology, mostly with the Bureau of Entomology (86 and 70); Agricultural engineering, largely with the Bureau of Agricultural Engineering (68 and 68); Forestry in all its aspects, mostly with the Forest Service (25 and 29); Foods and food-management practices, chiefly with the Bureau of Home Economics (10 and 9); Conserving and controlling wild life, mainly with the Bureau of Biological Survey (0 and 5); and Meteorology, mostly with the Weather Bureau (6 and 3). One of the unexplained shifts was the large decrease in coöperative projects in agricultural economics at a time when the subject was of growing importance. It probably was occasioned by heavy cuts in the Federal appropriations to the Bureau of Agricultural Economics.

Coöperative Use of Federal Facilities in Washington, D. C.

There are multitudinous coöperative investigational enterprises conducted by Federal and State agencies in the field within the various States. It was long ago recognized that there might be a reciprocal relationship in which representatives of the States would come to Washington to take advantage of the abundant facilities existing there for both bibliographic and laboratory research. Congress recognized the desirability of such relations as early as 1892.

A Joint Resolution of Congress was passed on April 12, 1892 (U. S. Stats. L, 27:395) having in view the promotion of State use of Federal facilities. The immediate cause of the action, as shown by the resolution, was the feeling that advertising the educational and research advantages of the Federal government might encourage the endowment of a national university in Washington. The Resolution was as follows (20:45; 30:123):

Joint Resolution To Encourage the establishment and endowment of institutions of learning at the national capital by defining the policy of the government with reference to the use of its literary and scientific collections by students.

Whereas, Large collections illustrative of the various arts and sciences and facilitating literary and scientific research have been accumulated by the action of Congress through a series of years at the national capital; and

Whereas, It was the original purpose of the government thereby to promote research and the diffusion of knowledge, and is now the settled policy and present practice of those charged with the care of these collections specially to encourage students who devote their time to the investigation and study of any branch of knowledge by allowing to them all proper use thereof; and

Whereas it is represented that the enumeration of these facilities and the formal statement of this policy will encourage the establishment and endowment of institutions of learning at the seat of government, and promote the work of education by attracting students to avail themselves of the advantages aforesaid under the direction of competent instructors; Therefore,

Resolved . . . That the facilities for research and illustration in the following and any other government collections now existing or hereafter to be established in the City of Washington for the promotion of knowledge shall be accessible, under such rules and restrictions as the officers in charge of each collection may prescribe, subject to such authority as is now or may hereafter be permitted by law, to the scientific investigators and to students of any institution of higher education now incorporated or hereafter to be

incorporated under the laws of Congress or of the District of Columbia, to wit:

- | | |
|--------------------------------|--------------------------------------|
| 1. Of the Library of Congress | 7. Of the Department of Agriculture |
| 2. Of the National Museum | 8. Of the Fish Commission |
| 3. Of the Patent Office | 9. Of the Botanic Gardens |
| 4. Of the Bureau of Education | 10. Of the Coast and Geodetic Survey |
| 5. Of the Bureau of Entomology | 11. Of the Geological Survey |
| 6. Of the Army Medical Museum | 12. Of the Naval Observatory |

A briefer statement to the same effect was contained in an urgent deficiency bill passed by the Congress in 1901, in which some additional institutions were named (30:124).

This principle of the coöperative use of Federal facilities was reaffirmed twenty years later by the Committee on Educational Courses (Graduate School) in the U. S. Department of Agriculture, when these courses were founded in 1922.

It is clearly the intent of Congress, as well as the desire of the administrative officers of Federal scientific establishments, to afford the fullest practicable use of their facilities to qualified students from other institutions. Such students would include, among others, the officers of State scientific and administrative establishments and the faculties and students of State educational institutions. The same principle applies equally to Federal facilities developed outside of the District of Columbia on an increasing scale since the enactment of this resolution in 1892.

Joint Committees and Conferences

Ever since the State agricultural colleges were founded, and especially since the system of State agricultural experiment stations was established, the promotion of coördinated effort through joint committees and conferences has been an accepted part of their program. This section on the research phases of the agricultural education program would be incomplete without some presentation of what has been accomplished by these agencies.

Joint Committee on Projects and Correlation of Research.—Field investigations by different units of the Federal Department of Agriculture began to develop on a large scale during the first decade of the present century. Some of these were in coöperation with State Agricultural Experiment Stations. During the same

decade demonstrational activities by the Federal Department were begun in both the southern and the northern States. These involved personal contact with individual farmers by representatives of the Department, but not necessarily in coöperation or understanding with the State institution.

In 1913 the Lever Bill providing for a national system of co-operative extension work was introduced in the Congress. This brought the entire question of the relations between the U. S. Department of Agriculture and the State Colleges of Agriculture into the limelight as a subject for vigorous discussion. At the annual convention of the Association of Land-Grant Colleges and Universities in November, 1913, two papers presented the subject from the State and Federal standpoints, respectively (2—27 (1913): 117—42; 10; 19). In the business meeting of the Association, provision was made for the appointment of a joint committee on projects and correlation of research. This was the outgrowth of a conference held previously between the Executive Committee of the Association and the Secretary of Agriculture, which resulted in the agreement to appoint such a joint committee, consisting of three members from each agency. The chairmanship of the committee has remained with the Land-Grant College Association. The chief of the Office of Experiment Stations has been one of the Federal members of the joint committee since its creation. Since 1921, when the position of Director of Scientific Work in the Department was created, that officer likewise has been one of the departmental members of the committee.

The Executive Committee of the Association prepared a memorandum for the joint committee, which is quoted below (2—28 [1914]:110):

Memorandum for the Joint Committee on Projects and Correlation Outlining Its Functions:

It is believed that the time has come when the organized efforts to improve the agriculture of the United States have assumed such large proportions, are supported by funds from so many sources, and are carried on by so many agencies that a point has been reached where a comprehensive survey should be made of the work done under the various appropriations of Congress to the United States Department of Agriculture and to the state agricultural colleges and experiment stations, and by the legislatures and other agencies in the various states. This should be done in order that the various lines of work may

be compared and the expenditures analyzed with a view to suggesting such correlation of effort as may be necessary to insure economy of time, money, and effort and increased efficiency of work. To this end the Association of American Agricultural Colleges and Experiment Stations and the Secretary of Agriculture have agreed upon the appointment of a joint committee on correlation of projects composed of representatives of the state and federal institutions to confer and suggest such modifications of present practice as may be found necessary to accomplish the desired purpose.

The function of the joint committee on correlation of projects should be to consider the regulatory, investigational, demonstrational and other extension work of the United States Department of Agriculture and the State Agricultural Colleges and Experiment Stations in so far as such work may bear upon agricultural practice or industries, in distinction from general agricultural education.

The purpose of this consideration should be the determination of the extent to which the work of these several agencies may conflict or overlap, with a view to determining what course of action may be necessary to insure the most effective use of federal, state, and other funds in accomplishing the purposes for which they are provided, by eliminating unnecessary and harmful duplication of effort and expenditure.

The committee should consider methods of formulating projects covering the work of the federal and state agencies with a view to bringing them into such form as will permit effective comparison to determine their character, purpose, and status, including their relative scope and magnitude and the sources from which their financial support is derived.

The committee should suggest such correlation of these projects as may appear advisable, especially such projects as from their nature or status involve features requiring administrative attention by either the department or the state agencies in order to bring them into harmony with such general policy regarding the relation of federal and state work as may be agreed upon.

From 1914, when the joint committee made its first report, until the present time, there has been increasing attention to the whole subject of the relation between the Federal Department of Agriculture, the State Agricultural Colleges and Experiment Stations, and the State Departments of Agriculture. The successive annual reports of the joint committee afford an interesting picture of the increasing development both of activities and of attitudes toward coöperation (2). Scores of papers have been presented and discussed in the annual convention. These have been concerned with coöperation, both between States and between individual States or groups of States and the Federal Department.

The joint committee in 1914 asked the State Agricultural Ex-

periment Stations and the U. S. Department of Agriculture for full information regarding their projects in the three fields of investigation, extension, and regulation. In their report to the annual convention in that year they recorded having received, from a majority of the States, fairly complete statements covering about 1300 projects, and statements of approximately 1000 projects from the Department of Agriculture.

In 1929 the joint committee reported that out of the total of more than 7000 State station projects, nearly 1100 were coöperative, a very large proportion involving coöperation with the U. S. Department of Agriculture. This number had grown from about 900 coöperative projects in the previous year, or an increase of 22 per cent. Of this number, 136, or 12.5 per cent, involved support from Purnell Act funds. There were 20 major regional projects in operation, involving groups of States varying from three to thirty-four in number as well as from one to three Bureaus of the U. S. Department of Agriculture. A fuller discussion of coöperative research projects is given under that heading in a later section of this chapter.

The special research committees created in 1925 and thereafter by the Association, and discussed in the next subdivision of this section, are in reality subcommittees of this joint committee, as their personnel is nominated to the Association by the joint committee, and the projects they formulate are subject to review by it.

Under the memorandum of suggestions and instructions given to the joint committee by the executive committee of the Association, they were directed to work towards a coördination and correlation of the activities of the State stations and the Federal Department of Agriculture. Under the law, the Secretary of Agriculture is directed to coördinate the activities of his Department with those of the stations. Obviously the joint committee, representing both the State stations and the Department of Agriculture, would be the official agency through which such coördination could be achieved. That this desirable result has not been obtained is a matter of common observation and knowledge, both within the Department and within the States. Independent activities of departmental agencies still continue in many States with a consequent division of allegiance on the part of citizens of the State and some resulting irri-

tation and distrust on the part of the State officials. Doubtless this condition arises in part from a conservative or laissez-faire attitude on the part of the committee. As pointed out in one of the addresses before the Association in 1913, many of those who feel most strongly on this subject within the States are loath to give voice to their views in public, either through fear of criticism or through fear of possible injury to the institution they represent.

After fifteen years of experience, the joint committee recorded its estimate of the development of a cooperative spirit in the following words (2-43 [1929] :203 and 205).

While the practice of cooperation or correlation has made steady growth, formal cooperation on the national projects, with an analysis of the subject and a division among investigators of the various things necessary to be done, has not made notable headway in most lines. For one thing, there is a lack of organization or of definite affiliation of individual workers with a constituted group. Such an organization of the projects as would insure their being covered systematically and recognized responsibility for integral parts has rarely been effected. Consciousness of membership in a common cause has not been a conspicuous product of operations under the national projects set up nearly five years ago.

The reason for this is not entirely clear. It suggests a lack of readiness to conform to a general plan such, for example, as is implied in the cooperation with the U. S. Department of Agriculture. The fact that a given investigator is working along the general lines of one of the national projects does not necessarily imply that he is actuated by any motive of joining his effort to that of others, or that the subject is being advanced in any more systematic or orderly manner. Organization of the problem, and to a certain extent of those working under it, seems essential to success in this type of research.

The broader relationships of research are believed to merit the studious attention of directors in planning their programs, and especially in inaugurating new projects or lines of work. Whether a subject in which there is regional or widespread interest shall be investigated independently and without due regard to what others are doing, or to the general advancement of the subject, assuredly is a matter for administrative consideration.

Research ought not to be regarded merely from the local standpoint. The experiment stations constitute a national system and they bear an intimate relation to the Federal Department of Agriculture. Correlation of their efforts is essential to economy of effort and efficient progress. After it has been effected there will still remain sufficient individual opportunity and institutional initiative for self expression.

Committee on Station Organization and Policy.—Since 1906, the Association has maintained also a standing committee on Ex-

periment Station Organization and Policy. While this is not a joint committee, the chief of the U. S. Office of Experiment Stations has been a regularly appointed member of this committee for the past eighteen years or more. As he is charged, under the Secretary, with the administration of Federal funds appropriated to the State stations, it is most fitting that he should be given membership on this important committee. Its annual reports are published in the Proceedings of the Annual Convention of the Association (2—20 [1906]—). The committee reports for 1906 and 1908 were published also in the *Circular* series of the Office of Experiment Stations (66—71 and 82), the last one being given in full only in the circular named.

Special research committees.—The Purnell Act, largely increasing the annual appropriations for the support of the State agricultural Experiment Stations, was passed in February, 1925. Thereupon the Executive Committee of the Association of Land-Grant Colleges and Universities called a conference to be held in St. Louis in April, 1925. This conference, composed of the administrative officers of the State Agricultural Experiment Stations, and of the U. S. Department of Agriculture, was to discuss plans for the administration of the funds appropriated by the Purnell Act. Other administrative officers and investigators in the several Bureaus of the Federal Department of Agriculture were authorized to attend for the purpose of promoting and developing plans for coöperative research on national problems.

Six national research projects were selected by the conference, as follows:

1. Distribution and marketing of farm products
2. Surpluses of farm products
3. Vitamin content of food in relation to human nutrition
4. Rural home-management studies
5. Rural social organization
6. Factors which influence the quality and palatability of meat

The conference authorized the Executive Committee of the Association to appoint special subject-matter committees to formulate project plans to be submitted to the several States with a view to their adoption in a nation-wide program of coöperative research. All plans submitted by the special committees were to be examined

by the Joint Committee on Projects and Correlation of Research. The Executive Committee appointed five subject-matter or project committees, Projects 1 and 2 having been combined.

These special committees met in Washington in June, 1925, and prepared project plans. These were examined by the Joint Committee on Projects and Correlation of Research and, after approval, were mailed to the State Experiment Stations. Those stations interested in each of the projects then developed plans for research thereunder, subject to the approval of the U. S. Office of Experiment Stations. These committees were first designated as "Special Purnell Committees," but at the thirty-ninth annual convention of the Association in November, 1925, the designation was changed to "Special Research Committees," the committees were continued, and provision was made for the annual reappointment of their personnel by the executive committee on nomination by the joint committee. The latter committee drafted a statement of their functions which the Association approved, as follows (2—39 [1925] :186) :

1. To study the problems already adopted for coöperation on a national scale in order to determine their content, the scope and character of the projects already set up under these problems, and what is further necessary to cover the field adequately.
2. To carry forward and supplement the plans already under way, with special attention to means of correlating and coördinating the investigations of the coöperators in such a way as to unify the efforts, avoid unnecessary duplication, and make the results comparable and supplementary.
3. To act as agencies for maintaining contact between coöperators and bringing together the ideas of individual investigators in respective fields, so as to make each undertaking a sustained, progressive, coöperative effort.
4. To canvass the field with reference to the proposal, from time to time, of additional national problems which it may be desirable to organize for coöperative efforts.
5. To act in an advisory capacity regarding research in their respective fields, especially as relates to definitions, correlation and policy in research.
6. To report to the joint committee on projects and correlation of research the general progress of the coöperative efforts in their charge, with recommendations of inaugurating new procedures or additional projects.

The California Experiment Station has been represented from time to time in the personnel of one or another of the special research committees. At the present time it has membership in the

one concerned with marketing and surpluses of farm products. It has established coöperative research projects in phases of the subject covered by two of them, namely, No. 1, Marketing, and No. 3, Vitamins.

Joint conferences.—The conference method of promoting desirable organization or legislation is of long standing in the field of research, as well as in other human activities. A conference of interested American agriculturists in 1852 resulted in the founding of the United States Agricultural Society, which, in turn, strongly supported the movement that eventually brought about the establishment of the U. S. Department of Agriculture and the Colleges of Agriculture and Mechanic Arts. Similar conferences on their mutual problems, held in 1882, 1883, 1885, and 1887, by groups of workers from these Land-Grant Colleges and the Federal Department of Agriculture, resulted in the promotion of Federal legislation which created the system of State Agricultural Experiment Stations and in the formation of the Association of American Agricultural Colleges and Experiment Stations in 1887 (36; 48—36:88-94 and 201-11).

Since these latter events, the conference method has been employed with increasing frequency in achieving correlation and cooperation in research and in promoting new investigations, both sectional and regional in scope. In recent years, such conferences of Federal and State administrators of experimentation and research are becoming more numerous. They are a natural outgrowth of the growing volume of coöperative activity in these fields and of the developing work of the joint committees of the Association of Land-Grant Colleges and the U. S. Department of Agriculture.

In scope, such conferences may be national, regional, sectional, or state-wide. They may be concerned with the entire field of agricultural research, with only a single division of that field such as animal husbandry or agricultural economics, or with but a single project, such as vitamins, corn breeding, or the economics of the combined harvester-thresher, or "combine." And any of these may be the business of a conference no matter what its geographic scope. A State conference might consider anything from the whole research field to a single activity, and the same might be equally true of a national conference. Examples of such conferences, to many

of which the University of California Agricultural Experiment Station has been a party, are numerous.

A national conference of representatives of all the State Agricultural Experiment Stations and of the U. S. Department of Agriculture was held at St. Louis, Missouri, in April, 1925. Its object was to discuss principles and practices germane to the program of expanded research about to be inaugurated through the enlarged funds provided by the Purnell Act, which, by 1930, was to treble the amount received by the State stations from the Federal treasury. The increase for each State was from the \$30,000 received under the Hatch and Adams Acts to a total of \$90,000 under the three acts. One feature of this program was a full discussion of the principles, benefits, and problems of coöperation as seen by the writer of this volume, then a representative of the U. S. Department of Agriculture who had had long experience in nation-wide coöperation in agricultural research (5). The principles involved had been set forth by the author previously (2—35 [1921]:158—162; 4).

Another example is the series of regional wheat conferences held a few years ago by representatives of Federal, State, and commercial agencies, to promote an enlarged and correlated program of research in the problems of wheat improvement, production, and protection, in the Western half of the United States. These were completely successful in accomplishing the desired objects. Equally significant have been the annual field conferences of Federal, State, and commercial agencies on the problems and results of the program for corn-borer control in America. These have been sponsored by a joint committee representing national organizations of agronomists, entomologists, and agricultural engineers, and others. In some years the field conference in summer was supplemented by a winter conference to interpret seasonal results and approve the research and control program for the following season. Another case in point is the long-continued series of annual meetings of the southern agricultural workers. Many others might be cited in other fields of agricultural science and practice.

Conferences of these kinds, though temporary and quite informal, perhaps are fully as effective in promoting and coördinating re-

search as the more formal methods often employed. The recent attitude of the Joint Committee on Projects and Correlation of Research toward such conferences is well expressed in their report for 1929, as follows (2—43 [1929] :204) :

In addition to formal coöperation there is a type of correlated research which grows out of group meetings or conferences of workers in a limited common field. Such conferences are quite free and informal, but they bring together those who have something to contribute to the common field and an interest in furthering investigation in the most effective manner. Their discussions bring out what is under way and the general status of inquiry, with the need for strengthening or extending the investigations in certain directions on the basis of results and the opening up of the subject. Needless repetition or duplication is incidentally checked, and the investigators are stimulated to make their work forward-looking in the light of the general judgment of the group.

Group contacts of various kinds are on the increase. They are regarded by some as the most effective type of coördinated research, especially in the advanced ranges and among mature specialists. Despite their informality, usually there is a nominal or accepted leadership—frequently some outstanding person, which serves to guide the effort and make it effective.

In less advanced fields, however, where the lines are not well marked out, and the research done has been scattering and somewhat desultory, more definite study of problems and organization of inquiry along specific lines still seems highly important. It has been somewhat slow in getting under way. The situation itself is an argument for more directed attempts toward correlation.

In short, the conference method of promoting, discussing, planning, or correlating research projects is becoming increasingly popular. Obviously, such conferences vary from informal discussion of existing or proposed research by a few persons to extensive program meetings with officers, committees, and the presentation of numerous assigned papers covering different phases of the problem and procedure in a broad research program.

Coöperative Publication Services

Publications resulting from Federal-State coöperation in research fall into two classes, namely, Federal publications containing summarized data on the work, expenditures, personnel, and publications of the various stations, and Federal or Federal-State publications containing or abstracting the results of their research.

Summarized station data.—The Office of Experiment Stations

of the U. S. Department of Agriculture prepares annually or at less frequent intervals several publications which summarize State experiment station data of one kind or another. Some have covered the work and expenditures of the stations. Others contain lists of station personnel, projects, or publications. This is a coöperative service because the stations themselves furnish the original information which the Federal agency summarizes and publishes. Such summaries are exceedingly helpful both to the stations and to the workers in other Federal and State agencies.

Station work and expenditures: It will be remembered that the Hatch Act of 1887 required each station to report annually to the State Governor on its operations and finances and to send a copy of this report to the Secretaries of Agriculture and the Interior, and to each other station. The Adams Act of 1906 required further that an annual report of receipts and expenditures be made by each station directly to the Secretary of Agriculture on schedules prescribed by him, and charged him with making an annual report to Congress on the receipts, expenditures, and work of the stations. The Purnell Act of 1925 repeated (Sec. 5) the Congressional requirement of a detailed annual report from the Secretary of Agriculture. The act making appropriation for the Department of Agriculture for 1915 also placed definite requirement upon the Secretary of Agriculture to furnish the Congress with detailed annual reports of the work of the agricultural experiment stations and the new agricultural extension services. For that and the two succeeding years these reports appeared as Parts 1 and 2 of a single report but with each part separately paged. As a matter of fact, the Office of Experiment Stations began the publication of annual reports on the work and expenditures of the agricultural experiment stations in 1896, although not required to submit such reports to the Congress until 1906.

From 1896 onward to the present time these summaries of station work and expenditures have been published annually by the Office of Experiment Stations, in four different classes of Office publications. Under the title "Work and Expenditures of the Agricultural Experiment Stations," or some slight variant thereof, they appeared in the *Circular* series (66—29) in 1896; in the *Bulletins* (64—50, 61, 83, and 93) from 1897 to 1900, inclusive;

in the *Annual Reports* of the Office (63) for the years 1901 to 1912, inclusive; and as unnumbered publications of the Office for the years from 1913 to date (68). For the three years 1915-17, the report comprised Part 1 of a combined report of the stations and the agricultural extension services. From 1925 to date the title has been *Report on the Agricultural Experiment Stations* (68). This annual publication, usually of more than a hundred pages, contains a philosophic discussion of various phases of research and administrative problems; statistics of projects, both total and co-operative, by subject-matter groups; a digest of work of the stations; a list of changes in personnel; a classified list of their publications during the year; and statistical financial summaries.

Lists of station projects: Beginning with the calendar year 1919, the Office of Experiment Stations has compiled and published at intervals a classified list of the projects carried on by the various agricultural experiment stations of the country (69). From 1919 to 1921 the lists covered calendar years. Beginning with 1922-23 they have covered fiscal years and, omitting 1924, were continued through 1927. These lists were mimeographed on letter-size sheets, the volumes increasing in size from 225 to more than 400 pages between 1919 and 1926 and appearing under the general title, *Classified List of Projects of the Agricultural Experiment Stations*. The mimeographed series ended in 1927. For the fiscal year 1930, the classified list was printed (48-89), in which form it comprised 252 pages. For the first time, this latest list shows which projects are coöperative between State stations or between States and the Federal Department of Agriculture. It was planned to publish thereafter at two-year intervals, but the financial situation has prevented.

Lists of station personnel: Beginning with the year 1889, the Office of Experiment Stations has published an annual list of the workers in agriculture in the State Agricultural Colleges and Agricultural Experiment Stations. The title of the publication has varied greatly in the forty-five years. Down to 1913 it was called an *Organization List* and since then has been designated *List of Workers*. In both periods the title has varied frequently. From 1889 to 1900, the title was *Organization Lists of the Agricultural Experiment Stations and Agricultural Schools and Colleges in the United*

States, or some relatively small variant of this. From 1901 to 1912 the order of the two classes of institutions was reversed, and the title, with some minor variations, reads, *Organization Lists of the Agricultural Colleges and Experiment Stations in the United States*. From 1914 to date the title in general has been *List of Workers in Subjects pertaining to Agriculture in the State Agricultural Colleges and Experiment Stations*, also with some minor variations in wording. In these annual lists the institutions are arranged in the alphabetical order of the States, and the workers are grouped by subject-matter divisions.

From 1889 to 1912 these lists were published in the *Bulletins* of the Office of Experiment Stations (64—1, 5, 12, 13, 19, 23, 27, 39, 47, 59, 74, 88, 111, 122, 137, 151, 161, 176, 197, 206, 224, 233, 247, and 253), with the single exception of that for 1891, which was published as a *Circular* (66—20). The issues for the years 1914 to 1922 were put forth as unnumbered publications. Those for the years 1914 to 1917, inclusive, were lists of the workers in agriculture in the Federal Department and in the State colleges and stations, printed in a single publication (70). In the issue for 1917 the list of Federal workers was paged separately from the list of State workers. For the years 1918, 1919, 1921, and 1922 (none apparently issued for 1920), the Federal list was issued separately as Part I and the college and station list separately as Part II (71). From 1923 to 1927 the lists were issued in the series of *Miscellaneous Circulars* (47—4, 17, 34, 58, 87). From 1928 to date they have appeared in the series of *Miscellaneous Publications* (48—12, 43, 67, 100, 134, 154, 180, 214, 234, 254, 299). The lists show the names, college degrees, and technical titles of the personnel, and conclude with an alphabetical index.

Lists of station publications: From time to time the individual State stations issue lists of their own publications, either complete, or of those still available. Only the Federal Office of Experiment Stations is in a position to compile and issue combined lists of the publications of all the stations. This it has done, in a limited field. Its recent compilations cover only the technical publications of the stations, including such series as their bulletins, technical bulletins, research bulletins, memoirs, and technical journals such as *Hilgardia*, published since 1925 by the University of California

Agricultural Experiment Station. Annual reports are included only when they have appeared in the bulletin series. Papers containing results of station research but published in the *Journal of Agricultural Research* and other scientific journals are not listed in these compilations.

The first attempt to list all the publications of the stations was made in 1892, when a list of all annual or biennial reports, bulletins, special bulletins, meteorological bulletins, and circulars issued to the end of 1891 was published in the third volume of the *Experiment Station Record* (12—3 [12]:936-70), in 1892. The second compilation (64—180; 72) listed all the technical publications, numbered or unnumbered, from the dates of the establishment of the several stations to June 30, 1906. The third compilation (43—1199; 73) listed these publications from the dates of station establishment to the end of the calendar year 1920, and was published in 1924. Thereafter, similar compilations were issued for each of six two-year periods, ending with that of 1931-32. The first three were published as *Supplements* (43—1199, Suppl. 1, 2, and 3; 74) of *Department Bulletin* No. 1199, the previous compilation, and appeared in 1924, 1926, and 1927 respectively. The fourth, fifth, and sixth, covering the periods 1927-28, 1929-30, and 1931-32, were published in the series of *Miscellaneous Publications* (48—65, 128, and 181; 74), and appeared in 1930, 1932, and 1934, respectively. Two have been issued since (48—232, 294).

Card index to station literature: In or about 1900 the Office of Experiment Stations developed a plan for publishing on library cards a subject index to the literature of the agricultural experiment stations and kindred institutions (66—22). A committee on indexing agricultural literature was created by the Association of American Agricultural Colleges and Experiment Stations, and reported its findings to the Association (64—142 [1903]). This report was published also by the Office of Experiment Stations (66—54). Other circulars describing the key to the subject index (66—23) or the card index itself (66—47) were issued, and the latter was revised at intervals at least until 1909.

The card index itself, or bibliography of station and related literature, showed the author, title of article, place of publication, reference to its abstracting in the *Experiment Station Record* and

a condensed statement of the contents. The classification was on a decimal system, the key numbers being printed on the cards. The cards as prepared were printed in quantities sufficient to supply the agricultural experiment stations and other subscribers.

The Library of Congress also has compiled and printed, since January, 1901, catalog cards for accessions (40). These cards already number nearly 1,000,000, and the number of subscribers exceeds 5,000, including libraries, firms, and individuals.

Research publications.—The results of coöperative research may be published in the bulletins and other publication series of the Federal Department of Agriculture or in similar series of the several State stations. They also may appear in the *Journal of Agricultural Research*, maintained jointly by the Federal-State agencies named. Many of them appear in privately published technical journals also. The volume of research publication in agriculture has become enormous.

The abstracting of the literature of agricultural investigation is a business in itself. Abstracts summarize extensive literature for the busy worker and make available to him the results contained in many papers which otherwise he could not hope to see. Only an extensive coöperation of State and Federal agencies has made possible the prompt abstracting of research literature and the placement of the abstracts in the hands of the workers who use them.

Coöperative bulletins: In formulating programs of research or survey coöperative between the Department of Agriculture, or other Federal agencies, and a State or group of States, it usually is provided that the results may be published by either or both of the contracting parties. In some cases it is provided further that the manuscript shall be submitted to the other party for reading and approval in advance of publication.

The acknowledgment of coöperation may appear on a coöperative publication in one or more of various ways. It may be printed on the outer cover page, on the inner cover page, in the scientific titles of the author or authors, as a footnote at the bottom of the first text page, as a statement in the introductory chapter, in the discussion of the history and organization of the experiment, in the titles of tables, or in any two or more of these places. It is most

desirable, of course, that it appear on the outer and inner title pages, because these are the most conspicuous locations. The announcement of the coöperation on the title pages is much fairer to the nonpublishing coöperator than is the relatively obscure footnote, usually in small type, or the later textual statements which are discovered only by a reading of the contents. Examples of these different forms of acknowledgment of coöperation have been discussed in the various chapters of this volume.

With the exception of dwellers in the District of Columbia, the people making up the constituency of any Federal coöperating agency are also the constituency of a State agricultural experiment station. Whatever a Federal agency publishes, therefore, whether coöperative or not, is intended primarily for the constituency of the State stations. When a publication representing coöperative studies within a State is published by a Federal agency it is distributed to such mailing lists within that State, and others, as the Federal agency may choose. In addition, a supply is furnished to the coöperating State agencies for distribution, or the Federal agency mails copies direct to lists furnished by the State agency, or both procedures may be followed. Under legislation enacted by the Congress, publications of the State experiment stations as well as those of Federal agencies, are carried in the mails without postage.

Under authority of law, the Superintendent of Documents of the Government Printing Office is allowed to print an extra supply of any Federal publication for an outside agency, and charge for it only the extra cost of paper and press work, provided the order is placed at the time the original Federal publication is printed. Where a coöperative paper is published by a Federal agency, therefore, the coöperating State agency may obtain any supply desired, without having to pay the high initial cost of type setting, which charge is borne by the Federal Government.

There have been cases in which at least four States and the U. S. Department of Agriculture have united in the preparation of a single joint publication, each State buying a supply of reprints of its own portion for separate distribution within its borders, while the Department of Agriculture distributed the entire publication. Arrangements may be made also whereby a State cover

for a coöperative publication published by Federal agency may be printed and attached at State expense by the Superintendent of Documents, replacing the Federal cover of the original publication. State saving by these practices is very great.

Many bulletins containing the results of coöperative investigations are issued by the State agricultural experiment stations. The coöperative relation is shown in the same diversity of ways as in the Federal bulletins. In many State bulletins the name of the coöperating Federal agency is more prominently displayed on the covers than is true of corresponding Federal publications. This is due in part to greater flexibility in choice of type for cover statements on State publications, as compared to the more uniform rules of the Government Printing Office, where virtually all Federal printing must be done. In part, the difference may be due to a greater appreciation of the advantage of coöperation by State personnel.

Journal of Agricultural Research: The Journal (23) was founded in October, 1913, and completed its forty-sixth volume on June 30, 1933. Journal publications had been issued by the Department of Agriculture previously, but they had been limited in subject matter to the scope of a single bureau, whereas the *Journal of Agricultural Research* covers the entire field of scientific agriculture, including forestry and engineering.

The first two volumes contain contributions only from the Department of Agriculture. Coöperative publication of station articles, however, was in mind from the very beginning. In the Foreword by B. T. Galloway in the first number of Volume 1 the following statement occurs:

The first few issues will contain papers from the Department of Agriculture only. Plans, however, are now being perfected in accordance with the tentative suggestions made to the Secretary of Agriculture by the Executive Committee of the Association of American Agricultural Colleges and Experiment Stations so that articles prepared and submitted by investigators in the State agricultural colleges and experiment stations will eventually be included in the Journal.

Definite coöperation with the State Agricultural Experiment Stations was provided for by the appointment in 1913 of an editorial committee of three persons, by the executive committee of

the Association, to represent the Association and approve manuscripts submitted by the stations for publication in the *Journal*. Beginning with the first number of volume 3, in October, 1914, the cover of the *Journal* carried the statement, "Published by Authority of the Secretary of Agriculture, with the coöperation of the Association of American Agricultural Colleges and Experiment Stations." On the inside it carried the names of the editorial committee of six, of whom three were "For the Department" and three "For the Association."

Full responsibility for acceptance of manuscripts submitted by the State stations has rested with the three members constituting the Association committee. Since the beginning of volume 29, on July 1, 1924, the name of this editorial committee has been "Joint Committee on Policy and Manuscripts." The official name for this committee given by the Association of Land-Grant Colleges and Universities was Committee on Publication of Research. A discussion of editorial policy was published (48—3) in 1927 and revised in 1932. Another discussion of policy and function was published in 1930 (27).

The California Station was not represented by papers in volume 3, the first after the coöperative arrangement was begun. Two papers from this station appeared, however, in the first issue of volume 4, in April, 1915, and a third paper appeared later in the same volume. Up to the end of October, 1930, California had contributed 53 papers to the *Journal*, being exceeded in number of contributions only by the Minnesota and Kansas Stations, both of which conduct a very large volume of research in coöperation with the U. S. Department of Agriculture. All the States except Connecticut have taken advantage of this medium of publication. The entire cost of publishing the *Journal of Agricultural Research* is borne by Federal appropriations. The average cost of the semi-annual volumes, of some 1200 pages each, is about \$11,000, or about \$22,000 per year. Up to October 31, 1930, the State experiment stations had published 755 papers, and the Department of Agriculture 1289 papers, in the *Journal*. Many papers in both groups were of coöperative origin. The proportion contributed by the stations is nearly 37 per cent. Of the 755 station papers, California has furnished 53, or 7 per cent.

Abstracting Journals.—The State experiment stations established in the several States by Act of Congress effective July 1, 1887, were required to issue bulletins or reports of progress at least once in three months, or four times a year. It was the desire of the Federal Office of Experiment Stations to make available to all station workers the results of all station work. This was accomplished for the first year (1888) by the publication of a bulletin (64—2) containing digests of the matter in the annual reports of the stations for 1888. Its two parts comprise some 430 pages. In 1893 the Office issued its *Handbook of Experiment Station Work*, a 400-page popular digest of the work of the various State experiment stations for their first five years, more or less (64—15).

Experiment Station Record. In 1888 plans were made for prompt publication of abstracts of experiment station results in journal form and the *Experiment Station Record* was the result (12). Its publication was begun in September, 1889, the first volume being completed in June, 1890. In the forty-four years since that time sixty-eight volumes have been issued. During the last several years two volumes, each consisting of nine abstract numbers and one index number, have been issued annually, each volume containing approximately a thousand pages. In the autumn of 1932 a change was made back to a volume of six large monthly issues and index number (12—66:401—4). The *Record* provides current abstracts of substantially all experiment station literature in this country, as well as of many important papers issued by experiment stations abroad. It includes, also, abstracts of Federal publications and of articles appearing in many current journals, whether written by experiment station workers or not.

Each experiment station is expected to send promptly to the Office of Experiment Stations, in the United States Department of Agriculture, copies of each of its publications as soon as they appear. These are made immediately available to the abstracting staff. So well is the work organized and conducted, and so promptly is the printing done, that the printed abstract may be in the hands of station workers within three or four months from the time the abstracted bulletin or journal is issued. From time to time, the editor of the *Record* discusses matters affecting this abstracting journal with the Association of Land-Grant Colleges and Univer-

sities or with the directors of the several State experiment stations (26).

Each volume has its own index. In addition, five volumes of combined indexes have been issued, covering the first sixty volumes of the *Record*, for the years from 1889 to 1929, inclusive. The first volume is a combined index of volumes 1 to 12; the second, of volumes 13 to 25; the third, of volumes 26 to 40; the fourth, of volumes 41 to 50; and the fifth, of volumes 51 to 60, inclusive. These five volumes of indexes comprise nearly four thousand pages (75).

Biological Abstracts: This (7) is a comprehensive abstracting and indexing journal of the world's literature in theoretical and applied biology, exclusive of clinical medicine. It is published under the auspices of the Union of American Biological Societies with the coöperation of biologists generally. It consists of an annual quarto volume of some 1200 pages. Volume 1, covering the biological literature of 1926, was issued during the year 1927, and volume 8 is appearing in 1934.

In 1929, *Biological Abstracts* entered into a coöperative agreement with the United States Department of Agriculture whereby an associate editor, especially concerned with agricultural literature, was quartered in the Department library, and has immediate access to current publications. The Department also pays the cost of transportation of the abstracts of agricultural literature to and from the section editors. A further coöperation is had with the *Experiment Station Record* of the Department, whereby carbon copies of the abstracts prepared for that journal are made available to the editor of *Biological Abstracts*, for use either with or without revision.

Many of the section editors and abstractors for *Biological Abstracts* are members of the staff of the U. S. Department of Agriculture, or of the State experiment stations. Theirs is a voluntary service, rendered without compensation, for the betterment of American biology, including agriculture. It is from the viewpoint that such a journal is of the highest technical value to its workers that the Federal Department of Agriculture coöperates by its contribution of personnel, material, and funds.

Biological Abstracts succeeded to and greatly amplified the work of an earlier abstract journal, called *Botanical Abstracts*. During

the years 1918 to 1926, inclusive, fifteen volumes of this abstracting journal were issued, together with a cumulative index to the first ten volumes. The publication known as *Chemical Abstracts* performs a similar service for agricultural workers in chemical fields. While no official coöperation has existed with either of these journals, their editors and abstractors include many Federal government and State experiment station workers.

The publications listed in the Literature Cited at the end of this chapter which have been cited in this section on Agricultural Experimentation and Research are Nos. 1, 2, 3, 4, 5, 7, 9, 10, 11, 12, 19, 20, 23, 27, 30, 36, 37, 38, 39, 40, 43, 46, 47, 48, 50, 51, 52, 56, 60, 62, 63, 64, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 80, 89, 94, and 95.

4. AGRICULTURAL EXTENSION

THE THREE MAJOR METHODS of agricultural education are by resident teaching, agricultural research and its published results, and extension teaching by lecture and demonstration. The first two were discussed in the preceding sections of this chapter. The third is the subject of the present section, and there yet remains a discussion of certain information services not logically belonging to any of these three. Agricultural extension was done almost wholly by the meeting and lecture method until 1904, and largely so during the succeeding decade, and until the enactment of the present legislation. Since 1914, extension has been chiefly by the method of demonstration. The entire movement has been exceedingly rapid and yet so fundamentally important to our agricultural industry that its history already has been well written (29, 35, 48—15). Much of the historic summary presented here has been derived from the comprehensive volume by True. A bibliography of agricultural and home-economics extension in the United States (18) was issued in 1928.

Relations between the various States and the Federal government began long before the enactment of the existing extension legislation in 1914 and thereafter. In 1905, the Association of American Agricultural Colleges and Experiment Stations created a standing committee on extension work (2; 66—72 and 75). This committee asked the assistance of the Office of Experiment Stations and presently chose Professor John Hamilton, the farm-

ers' institute specialist of that Office, as the secretary of the committee. In 1909, the Association created a third coördinate section, the Section on Extension Work (66—98). The coöperative relations between the Federal and State agencies developed steadily until they became mandatory under the Federal Smith-Lever Act of 1914.

EARLY EXTENSION ACTIVITIES

Agricultural extension began in a crude and limited way at about the beginning of the last century, through the efforts of public-spirited members of the various regional agricultural societies. This was continued on an expanding scale by the county agricultural societies which began to be formed about 1810. By 1825 the formation of local farmers' clubs was under way, to increase at the rate of more than a hundred a year for several years. They naturally became the centers of much agricultural extension by lecture and by demonstration. Both local and regional agricultural fairs, which developed rapidly during the same period, played their part in this movement. There was little official coöperation during this long period.

Farmers' Institutes

From about 1852 onward, the chief means of agricultural extension was the farmers' institute, sponsored increasingly by State agencies. The Office of Experiment Stations, created in the U. S. Department of Agriculture in 1888 to administer the Hatch (Agricultural Experiment Station) Act of 1887, was quick to see the importance of extension agencies as disseminators of the results of station experiments (62). Federal coöperation with the farmers' institute movement dates from about 1889 when the Office of Experiment Stations began collecting data on these educational extension agencies. In 1900 a Federal appropriation of \$2000 was made available for this purpose, and later was increased considerably. The Office became the national clearing house for information regarding these organizations, and many publications resulted on history and status (64—79 and 174; 43—83 and 269), lists of directors and lecturers (66—51, 105, and 114) with many revisions between 1903 and 1914, and, finally, compilations of legislation (64—135 and 241).

In 1903 a specialist in farmers' institutes was added to the staff of the Office of Experiment Stations. An American Association of Farmers' Institute Workers had been organized in the spring of 1896. From 1901 to 1912 the proceedings of the sixth to the seventeenth annual meetings of this Association were published by the Office (64—110, 120, 138, 154, 165, 182, 199, 213, 225, 238, 251, 256). Federal participation in the farmers' institute movement continued actively until the newer types of extension activity gradually displaced it.

The farmers' institute movement began to develop special interests for farm women as early as 1890, and during the succeeding decade there was a widespread and intensive growth of this function of the institutes. Special features for the farm boys and girls were introduced as early as 1900 and developed rapidly thereafter. In the main, they followed many of the lines now used in the highly organized boys' and girls' club work (52—1904:489-96). The institute movement reached the climax of its career in about 1910 and then gradually gave way to the growing movement for farm and home demonstrations.

Railroad Agricultural Trains

In 1904, two Iowa railroads began coöperating with agricultural extension forces of the State Agricultural College in running special extension trains through farming areas. The trains were equipped with literature, exhibits, and lecturers, as well as dining and sleeping accommodations for the latter. This initial effort was devoted to better seed corn. The idea spread rapidly, and by 1906 the movement was under way in twenty-one States. The scope of the instruction was broadened to cover many of the problems of agriculture. In 1910 the Office of Experiment Stations gathered data on the extension activities of 103 railroads in the United States and Canada (66—112). The movement reached its peak in 1911 when seventy-one trains were run in twenty-eight States, with a total attendance of nearly 1,000,000 persons.

Coöperative Extension in Dairy Practices

The Dairy Division of the Bureau of Animal Industry was primarily an extension agency for many years, so far as its work in

the different parts of the United States was concerned. Exports of American butter and cheese had greatly diminished in the late eighties and early nineties because of poor quality and adulteration. The growth of cities had progressed rapidly without accompanying progress in the sanitation of milk production and handling. The Dairy Division undertook to remedy these conditions. The first ten years after its founding in 1895 were devoted to survey and the publication of the results of the observations made and of better methods of dairying. In this, it was quite different from most other Divisions and Bureaus.

In 1905, the Dairy Division began a program of coöperation with the Colleges of Agriculture in the various States which soon reached nation-wide proportions. The work was begun in the Southern States in 1905, extended to the Rocky Mountain and Pacific Coast States in 1910, and to the Northern and Middle Western States in 1915. This work was independent of the demonstration farm movement described farther on. In the South the expenses were borne wholly by the Dairy Division at first, with the understanding that the State would gradually take over the expenses of the work as it developed. By 1907, several of the southern States were providing assistants at public expense. In the Far West and the Middle West the work was coöperative from the start, in the latter area mostly on a half-and-half basis after 1916 (22:195). After the passage of the Agricultural Extension Act in 1914 much of the State coöperation was on extension funds and the subject-matter bureaus furnished men from extension funds also. In 1920 the Congress discontinued extension appropriations direct to subject-matter bureaus and the Federal men were taken over by the States (59).

Farmers' Demonstration Work

From 1904 until the end of the fiscal year 1914 the chief extension activities of the U. S. Department of Agriculture were centered in the Bureau of Plant Industry (85), with the exception of the limited coöperation in farmers' institutes and dairying just discussed.

In the southern States.—The advent of the cotton-boll weevil in the southern States in 1892 had created an increasingly serious agricultural problem. In 1904 Dr. Seaman A. Knapp set going his

well-known plan of coöperative farm demonstrations to teach the possibilities of diversified farming under boll-weevil conditions (46—248). Federal funds for protection against the boll weevil were made available for this work. An Office of Farmers' Coöperative Demonstration Work was established in the Bureau of Plant Industry. In 1906 the General Education Board began its contributions to this work, restricting its support to demonstrations in States or parts of States not yet affected by the weevil. This support was continued until 1914, when the Smith-Lever Act provided large funds for coöperative extension activities and discriminated against this type of contribution. Club work with boys was begun in 1907 and with girls in 1910. Home demonstration work with farm women seems to have started in 1912. The work was discussed in 1910 and 1912 (52—1909:153—60; 52—1911:285—96) and summarized for the years 1903 to 1921 (46—248).

At first the work was not conducted in coöperation with the State Colleges of Agriculture, although there were many informal relations. The colleges and experiment stations objected to Federal enterprises started in their States without their knowledge or participation. They objected also to the Federal coöperation with the State Departments of Agriculture and of Education, rather than with the agricultural educational institutions. As the enterprise grew, the intimate agricultural knowledge of the State college and station became more strongly needed. By 1909 some coöperation had been arranged with these agencies in four States. In 1912 arrangements were made for State-wide coöperation in three States, and in 1913 the number was doubled. For the fiscal year 1914 the total funds used in the South were \$950,000, of which about \$372,000 were Federal, \$187,500 were from the General Education Board, and \$411,000 from State, County, and local sources. The total number of agents, men and women, was 1138.

In the northern States.—In the meantime, in 1906, a series of farm-management demonstrations was begun in the northern States. The purpose of both movements was the same, namely, to improve farm practices. While the demonstrations in the south were set up on selected farms and were concerned primarily with diversified farming, those in the north were in part a study of farm-management methods and in part a demonstration of the best

method determined. The work began under regional and district agents and had progressed to the county-agent basis by 1910.

Movement for a Unified System

The success attending these extension movements led to consideration of a nation-wide system, and to recommendation of Federal appropriations therefor, by the extension committee of the Association of Land-Grant Colleges as early as 1908. Various bills were introduced in Congress from 1910 onward, but it was not until 1914 that any of them became law. Until the end of that fiscal year all of this work had been carried under the authority of annual appropriation acts.

When these two extension activities were more or less merged with the general agricultural extension movement in the fiscal year 1915, they occupied, between them, 929 counties (or nearly one third of the total number in the United States) and employed 1350 persons. Their funds aggregated about \$1,500,000.

EXTENSION LEGISLATION, 1914-1930

The present system of coöperative agricultural extension is financed under four specific pieces of legislation (46—251, *revised*) besides those extending the work to Alaska and Hawaii. These four acts are: The Smith-Lever Act of 1914 (20:229-33; 54-57), the Capper-Ketcham Act of 1928, the Supplemental Smith-Lever Appropriation Act of 1929, and the Clarke-McNary Forestry Extension Act of 1924. Each of these acts became effective for the fiscal year following the calendar year named.

The principal features of the Smith-Lever and Capper-Ketcham Acts are:

1. That the extension activities thereunder shall be coöperative between the State colleges of agriculture and the U. S. Department of Agriculture.
2. That annual reports of work and expenditures must be made to the State governor and through him to the Secretary of Agriculture and the Secretary of the Treasury.
3. That there shall be Federal approval and supervision both of extension projects and of expenditures.
4. That the appropriation of the first year be allotted to the States equally, but that the increasing additional appropriations thereafter be distributed on the basis of rural population.
5. That the States be required to make an offsetting contribution equal to

all allotments after that of the first year, either through appropriations or "individual contributions within the State," thus eliminating contributions from such foundations or corporations as the General Education Board.

Smith-Lever Act

"An Act to provide for coöperative agricultural extension work between the agricultural colleges in the several States receiving the benefits of an act of Congress approved July second, eighteen hundred and sixty-two, and of acts supplementary thereto, and the United States Department of Agriculture."

[Section 1] That in order to aid in diffusing among the people of the United States useful and practical information on subjects relating to agriculture and home economics, and to encourage the application of the same, there may be inaugurated . . . agricultural extension work which shall be carried on in coöperation with the United States Department of Agriculture . . .

Section 2. That coöperative agricultural extension work shall consist of the giving of instruction and practical demonstrations in agriculture and home economics to persons not attending or resident in said colleges in the several communities, and imparting to such persons information on said subjects through field demonstrations, publications, and otherwise; and this work shall be carried on in such manner as may be mutually agreed upon by the Secretary of Agriculture and the State agricultural college or colleges receiving the benefits of this act.

Section 3 of the act provided an appropriation of \$480,000 for the fiscal year 1915, this sum to be allotted equally to all States, thus giving \$10,000 to each. For the fiscal year 1916 an additional \$600,000 was appropriated, and for each of the next seven fiscal years, 1917 to 1923, the sum was increased by \$500,000 annually, reaching a grand total of \$4,580,000 in 1923, of which \$4,100,000, or all except the initial \$480,000, were required to be offset by an equal State contribution. All sums after the initial appropriation were to be allotted annually to each State in the proportion which the rural population of that State bore to the total rural population of all the States. The offsets might be provided through State appropriation, or by other State, county, college, local, or individual contributions from within the State.

Section 4 provided for semiannual payments by the Secretary of the Treasury, upon the warrant of the Secretary of Agriculture, to a State officer duly authorized by State laws to receive the funds, and required such officer to furnish to the Secretary of Agriculture annually a detailed statement of receipts and disbursements on forms prescribed by the Secretary of Agriculture.

Section 5 prohibited or restricted the expenditure of money for certain specified purposes, required the replacement by the State of any funds lost or misapplied before any subsequent appropriation should become available to such State, and required the college to make a detailed annual report to the State governor on the extension operations, including receipts and expenditures from all sources, a copy of said report to be sent to the Secretary of Agriculture and to the Secretary of the Treasury of the United States.

Section 6 required the Secretary of Agriculture to ascertain and to certify to the Secretary of the Treasury whether or not each State was entitled to receive its share of the annual appropriation and the amount to which it was so entitled. In case such certification was withheld from any State, it was required that the facts and reasons therefore be reported to the President and the funds involved kept separate in the Treasury for a specified time in order to allow for an appeal to Congress, by the State, from the determination of the Secretary of Agriculture.

Section 7 required the Secretary of Agriculture to make annual report to Congress on the receipts, expenditures, and results of the work in all of the States, together with the reasons for withholding the appropriations from any State.

Capper-Ketcham Act

The Capper-Ketcham Act of 1928 provided for an initial appropriation of \$980,000 for the forty-eight States and Hawaii in the fiscal year 1929 and increased this by \$500,000 to a total of \$1,480,000 in 1930, and thereafter. These additional funds were subject to the same conditions and limitations as those prescribed by the Smith-Lever Act, the final \$500,000 being conditioned on State offset in the same amount. The act further provided that at least 80% of the total appropriation should be used in paying salaries of county extension agents "to further develop the coöperative extension system in agriculture and home economics with men, women, boys, and girls," and provided further that the extension agents should be men and women in fair and just proportions.

Supplemental Smith-Lever Act

In the annual appropriation act for the U. S. Department of Agriculture for the fiscal year 1930, an additional \$1,480,000 were made

available for the coöperative extension work and an equal offset was required from States receiving the funds.

Clarke-McNary Forestry Act

This is a general forestry act rather than an extension act. It covers a wide range of coöperative and noncoöperative forestry activities, including fire prevention and fire suppression, studies of forest taxation, production and distribution of forest-tree seeds and seedlings for planting purposes, coöperative windbreak, wood lot, and reforestation planting, watershed protection, and national-forest expansion.

The act differs markedly from the extension acts previously discussed. In the first place it is general forest legislation. In the second place the funds are appropriated directly to the U. S. Department of Agriculture and not for allotment to the States, although coöperation with the States in their expenditure is directed, under certain conditions.

The Extension Service is concerned directly with section 5, covering the promotion of farm wood lots, windbreaks, shelter belts, etc. Less directly it is concerned with section 4 providing for the production and distribution of forest-tree seeds and seedlings, as these were designed to be supplied for the creation of the wood lots, windbreaks, and shelter belts referred to in section 5. The two sections referred to are quoted below:

AN ACT to provide for the protection of forest lands, for the reforestation of denuded areas, for the extension of national forests, and for other purposes, in order to promote the continuous production of timber on lands chiefly suitable therefor.

Section 4. That the Secretary of Agriculture is hereby authorized and directed to coöperate with the various States in the procurement, production, and distribution of forest-tree seeds and plants, for the purpose of establishing windbreaks, shelter belts, and farm wood lots upon denuded or nonforested lands within such coöperating States, under such conditions and requirements as he may prescribe to the end that forest-tree seeds or plants so procured, produced, or distributed shall be used effectively for planting denuded or nonforested lands in the coöperating States and growing timber thereon: Provided, That the amount expended by the Federal Government in coöperation with any State during any fiscal year for such purposes shall not exceed the amount expended by the State for the same purposes during the same fiscal year. There is hereby authorized to be appropriated annually, out

of any money in the Treasury not otherwise appropriated, not more than \$100,000 to enable the Secretary of Agriculture to carry out the provisions of this section.

Section 5. That the Secretary of Agriculture is hereby authorized and directed in coöperation with appropriate officials of the various States, or, in his discretion, with other suitable agencies, to assist the owners of farms in establishing, improving, and renewing wood lots, shelter belts, windbreaks and other valuable forest growth, and in growing and renewing useful timber crops: Provided, That except for preliminary investigations, the amount expended by the Federal Government under this section in coöperation with any State or other coöperating agency during any fiscal year shall not exceed the amount expended by the State or other coöperating agency for the same purpose during the same fiscal year. There is hereby authorized to be appropriated annually out of any money in the Treasury not otherwise appropriated, not more than \$100,000 to enable the Secretary of Agriculture to carry out the provisions of this section.

COÖPERATIVE PROCEDURE

During the fiscal year 1915, the U. S. Department of Agriculture created a States Relations Service (11; 35; 94; 95) to administer all Federal legislation affecting official relations between the Department and the State Agricultural Colleges and their agricultural experiment stations and extension services. The States Relations Service included as one of its divisions the Office of Experiment Stations and as another division the newly organized Coöperative Extension Work. The two previously existing lines of activity in farmers' coöperative demonstration work, discussed above, were not officially merged with the newly created Extension Service until the beginning of the fiscal year 1916, and the separate appropriations were not consolidated until several years later. The States Relations Service, although organized and functioning, did not issue a separate annual report for 1915. Its data for that year were included in the annual report of the Secretary of Agriculture (42—1915:38—44). The activities of the Extension Service during the war, also, have been recorded (28:136—46).

The extension activities coöperative between the Federal Department of Agriculture and the various State Colleges of Agriculture are governed in part by the specific requirements of the various legislative acts and in part by the terms of coöperative agreements developed through conference and signed by representatives of both organizations. The interrelations of the Federal,

State, and county agencies within the various States are governed wholly by coöperative agreement.

Data presenting the progress and results of these interrelations are published annually as required by law. The successive publications containing these facts have varied so widely as to series and as to title within a series as to be decidedly confusing to the user. From 1916 to 1923, inclusive, the States Relations Service was the coördinating Federal agency and the report of its director (86) was included with the reports of other Bureaus in the annual report of the Federal Department, except for 1921, when no volume containing all administrative reports was prepared and each Bureau report was issued only separately. At the end of the fiscal year 1923, the States Relations Service was discontinued and the Extension Service was created as a unit coördinate with the Office of Experiment Stations. Separate annual reports of the director of the Extension Service were published for the years 1924 to 1930, inclusive (76). Many of the data required by law were published with other data in these successive annual reports. Some of the data were published in other series. For the fiscal years 1921 to 1924, inclusive, statistics of coöperative extension work were published annually in the Department *Circular* series (46—140, 203, 253, and 306). During the fiscal years 1923 to 1929, inclusive, a comprehensive annual, *Coöperative Extension Work*, was issued as an unnumbered publication of more than a hundred pages. It contained full annual data on extension activities, including statistics of finance and personnel (78). For the fiscal year 1930, after this publication was discontinued, the statistical results were published in mimeographed form in a series of *Extension Service Circulars* (77—157). Beginning with fiscal year 1931, the annual reports of the Extension Service, the statistical information, and the more comprehensive data included in *Coöperative Extension Work* were consolidated into a single annual *Report of Extension Work in Agriculture and Home Economics in the United States* (79), also issued as an unnumbered publication.

Federal-State Administration

The relations between the Extension Service of the Federal Department of Agriculture on the one hand, and the Extension Serv-

ices of the State Colleges of Agriculture on the other, are in part mandatory under Federal legislation, and in part the result of coöperative agreements into which these agencies have entered.

Mandatory requirements.—The mandatory requirements on the two parties administering this joint activity are as follows:

1. The U. S. Department of Agriculture, under the terms of the Smith-Lever Act:

a) Reviews and approves the plans submitted annually by the University of California College of Agriculture (sec. 3);

b) Makes an annual allotment of the additional funds to the State (sec. 3);

c) Transmits warrants to the Secretary of the Treasury for the semiannual payments due to the State on January 1 and July 1 (sec. 4);

d) Ascertains and certifies to the Secretary of the Treasury annually, on or before July 1, the eligibility of the State to receive its allotment of funds (sec. 6);

e) Makes an annual report to Congress on the receipts, expenditures, and results of the coöperative agricultural extension work in all the States and on the facts regarding the withholding of funds from any State (sec. 7).

2. The State College of Agriculture Extension Service, under the terms of the Act:

a) Submits annually its plans of the work to be conducted in the next fiscal year for approval by the Secretary of Agriculture (sec. 3);

b) Certifies in advance the availability of the amount of State appropriations or other contributions required by law as an offset to the Federal allotments (sec. 3);

c) Submits annually, on or before September 1, a detailed report of receipts and expenditures in the previous fiscal year, on forms prescribed by the Secretary of Agriculture (sec. 4);

d) Submits annually, on or before January 1, a report of operations and expenditures to the governor of the State, and transmits a copy to the Secretary of Agriculture and to the Secretary of the Treasury (sec. 5).

Under the provisions of the Smith-Lever Act, and the regulations of the Postmaster General, publications and communications

dealing directly with the work of coöperative agricultural extension are carried free in the United States mails under the franking privilege of the United States Department of Agriculture, which effects a further financial saving to the individual States.

Voluntary agreements.—Coöperative activities between the U. S. Department of Agriculture and the various States are covered by a general memorandum of understanding. California, owing to conditions existing in 1915, is the only State which has not signed this general memorandum. The conditions, however, no longer exist. There has been a general informal understanding throughout this entire period that the work would be conducted in California in the same manner as in other States.

Coöperative activities within a State are governed by a series of signed projects. The administrative project, of which the latest revision was effected July 1, 1924, covers matters of administrative coöperation between the Federal Department and the State Agricultural College. It provides for the conduct of the work coöperatively, the establishment of headquarters and a State Director of Extension at the College, and for the organization of the work in the field primarily on a county basis. It also outlines the methods of procedure, including the coöperative responsibilities and duties of the State Director. There are several other signed projects, but these relate more particularly to the conduct of the work in the counties, and to the county organization, and therefore belong more properly to the next subsection.

Each year a program of work under the administrative project is prepared and submitted to the Federal Department of Agriculture. It covers the following activities: (a) budget and finance; (b) personnel; (c) general overhead supervision; (d) records and forms; and (e) visits to counties. It outlines also the responsibilities of the State Director of Extension under each of these major headings.

The official coöperation, as noted above, is between the U. S. Department of Agriculture and the State Agricultural College. There also is informal coöperation with virtually all the Bureaus of the Federal Department in the planning and conduct of the extension program. The various subject-matter extension specialists of the Department are quartered in the subject-matter Divisions and

Bureaus where they are in intimate daily contact with the research staff. Within the States there is coöperation in a similar way with various State Departments. Primarily these are the State Department of Agriculture and especially the Coöperative Crop-Reporting Service, and some agencies of the State conservation unit. Likewise, there is coöperation with the subject-matter divisions of the State Agricultural Experiment Station.

Planning extension programs.—A staff of subject-matter specialists is maintained both by the Office of Coöperative Extension Work in the United States Department of Agriculture and by the Extension Service of the State Agricultural College. These specialists cover nearly the entire subject-matter field, including, for example, agronomy, horticulture, forestry, animal husbandry, dairying, irrigation, agricultural engineering, foods and nutrition, textiles, home management, and boys' and girls' club work.

There is much voluntary collaboration between the two groups, in addition to the required coöperation in formulating State programs on the one hand, and their approval by the Federal agency, on the other. In the voluntary coöperation, the principal function of the Federal specialists is to assist in coördinating State programs by bringing to each State the best ideas and procedure developed by any other State. They act also, as advisers, in helping to formulate programs for counties or groups of counties within the State.

In the western States, comprising the nation's newer agricultural areas, the program of agricultural extension faced many new problems. For this reason, regional conferences rather than State conferences were held. These included not only the extension specialists of the U. S. Department of Agriculture and of the western States involved, but also representatives of the research projects in various bureaus of the Department of Agriculture and divisions of the State Experiment Stations. Some of the programs evolved in these conferences were published for the benefit of the research and extension agencies mutually concerned with the problems (46—308, 335, 375; 48—8).

The primary function of the subject-matter specialists on the State staff is to formulate subject-matter programs in consultation and coöperation with the county farm advisor and his associates,

and to correlate these programs in counties having similar conditions and programs. They also inaugurate and conduct special programs in those more difficult subjects for which the regular county extension staff has little time or training, such as farm efficiency studies, marketing studies, forest-fire prevention, and education.

Federal-State-County Operations

The previous subsection was concerned with the administrative relations between Federal and State agencies. This subsection is concerned with the actual coöperative conduct of extension work in agriculture and home economics in the various counties of a State. California is typical for purposes of illustration.

Extension history in California.—Agricultural extension activities in California, as in most States, antedate by many years the passage of the Smith-Lever Act in 1914. Farmers' institute work in California was begun in 1892, the necessary funds being provided for eleven years through allotments from the general funds of the University of California. In 1903, the State legislature passed an act specifically authorizing the Regents of the University to hold farmers' institutes, and making an appropriation of \$6000 for the biennium. With this sum, extension activities were greatly expanded, and soon became state-wide. In 1909, the amount was increased to \$20,000 for the biennium, or \$10,000 a year. Under this increased appropriation, the work was expanded to include not only farmers' institutes, but also reading courses, correspondence and special visitations, assistance to schools in teaching agriculture, and the promotion of demonstration trains.

In 1913, during the agitation for the passage of the Smith-Lever Agricultural Extension Act, the University of California College of Agriculture anticipated its passage by creating a Division of Agricultural Extension. The College then entered into coöperation with the United States Department of Agriculture, with a view to locating agricultural advisers throughout the State. In the same year, 1913, a coöperative agreement was made with the Board of Supervisors of Humboldt County whereby a "Farm Advisor" was placed in that county, with headquarters at Eureka. This was the beginning of the present system of county agricultural extension in California.

When the Smith-Lever Act was approved on May 8, 1914, immediate steps were taken to expand the county work. Even before Federal funds became available on July 1, four additional farm advisors were appointed almost immediately, and six additional counties made the necessary appropriation and awaited the appointment of a farm advisor in each. The organization then effected is the same which has since been in continuous operation in California.

With the passage of the Clarke-McNary Act in June, 1924, the State Agricultural Extension Service entered into a coöperative arrangement with the U. S. Department of Agriculture and the Division of Forestry of the College of Agriculture in the appointment of an extension forester.

With the expansion of the allotments from Federal appropriations brought about by the successive agricultural extension acts, the coöperative work in California was steadily increased. One of the principal new lines of activity established was extension teaching in marketing, under the special act providing funds for that purpose.

At the end of the first year under the Smith-Lever Act, it was estimated that about forty counties out of the total of fifty-eight would require the organization of a county extension system. By 1920 the work had been organized in thirty-seven counties. At the present time, resident extension advisors are maintained in forty counties of the State. In five others, the work previously organized has been discontinued. In four of these counties such action was taken by the Board of Supervisors, as a result either of the agricultural depression, or of reactionary agitation, or both. In the fifth county, Inyo, the action was taken in 1926, on recommendation of the State Director of Agricultural Extension, owing to the inclusion of a large part of the agricultural area of the county in the tracts purchased by the city of Los Angeles to protect the sources of its city water supply. One of the four counties mentioned above has reestablished extension activities, and it seems probable that a second will do so within a short time.

Coöperative activities in California counties.—The Smith-Lever Act in Section 2 defines coöperative agricultural extension work as "the giving of instruction and practical demonstrations in agri-

culture and home economics to persons not attending or resident in said colleges in the several communities, and imparting to such persons information on said subjects through field demonstration, publications, and otherwise." The object is to bring the information obtained by the Agricultural College and Experiment Station, and the U. S. Department of Agriculture, to the individual farmers and home makers in order that, through better organization and practices, there may be an increased net return and an improved rural life for the farm family.

The work of the county farm advisor and his assistant advisors is to furnish, to those who desire his services, assistance by advice or demonstration on soil treatments, fertilizer practices, crop adaptation, culture, and protection, animal production and protection, farm organization and management, and farm-product marketing. On the side of improving rural life, he promotes better roads, schools, community organizations, farmers' organizations, and marketing facilities.

The work of the county home-demonstration agent and her assistants is to furnish, to those who desire her services, advice and demonstration on foods and foodstuffs; the home preservation of fruits and vegetables; better utilization of waste products of the home, orchard, and garden; economical purchase and use of textiles, and better utilization of worn garments; improved methods of gardening and poultry raising; better facilities for standardizing home products; household sanitation, and the saving of time and strength through the introduction of labor-saving devices. She likewise promotes those community forces and agencies which make for a better rural life.

The county farm advisor and the county home-demonstration agent and their assistants are instructed not to visit any farm unless invited to do so. In the early days of the movement, personal contacts were sought by these agents, but now that the scope and purpose of the enterprise are fully known, it is felt that the initiative should rest with the person seeking assistance. In the same way, where concerted community action is necessary to the successful prosecution of the methods which have been advised, the people themselves must take the necessary steps to that end.

The work is restricted to educational activities applied to agri-

culture and home economics. This debar members of the extension force from rendering personal services which farmers should do for themselves; from advocating specific legislation, although they may advocate the principles on which such legislation might be based; from soliciting membership for, or holding offices in, farmer organizations; and from buying or selling products or supplies from farmers. All the above are joint policies of the U. S. Department of Agriculture and the University of California.

With the passage of the Clarke-McNary Act providing, among other things, for forestry extension, beginning with the fiscal year 1925, assistance has been given to farm owners, farm communities, and organizations in establishing, improving, and renewing wood lands, shelter belts, and windbreaks; in promoting the protection of watersheds; in growing and renewing useful timber crops and in marketing or utilizing them; and in teaching the proper utilization of forest products in agriculture and the economic relations between farm and forest.

Under recent legislation, creating extension work in marketing, it becomes the duty of the coöperative extension forces to instruct farm people in correct principles and practices in marketing farm products, particularly with reference to coöperative marketing, in order that marketing associations may be formed upon proper bases for successful operation, and may be sustained by a farm membership.

One of the special and very important activities of the coöperative extension service is the directing of work with boys' and girls' clubs. These clubs are standardized in organization and activity, and are members of the nation-wide organization. They are formed on a commodity or subject basis; that is, each club has a particular subject-matter objective, such as pig raising, calf raising, home canning, or dressmaking. Specific work is assigned to each member, operations are supervised, and credits given for satisfactory accomplishment. It may be noted that projects dealing with farm crops, orchard crops, or livestock are not restricted to boys' clubs. These clubs of boys and girls have become widely known in recent years under their later name of 4-H clubs. The four H's are head, heart, hand, and health. The badge is a four-leaf clover, with an H on each leaflet.

Within the county, in addition to the official coöperation with the Board of Supervisors, there is informal coöperation with the County Superintendent of Schools. As the extension work is agricultural, there is informal coöperation with substantially all agricultural organizations and agencies in California. This applies not only to the organizations concerned with producing, processing, and marketing agricultural products, but also to farm, forest, and commercial organizations. The chief coöperative activity of these various organizations is the furnishing of information to be used for educational purposes.

The general conduct of extension work within the counties is covered by two principal projects. The first provides for extension work in agriculture and home economics by means of county extension agents, and is signed by the Federal and State Directors of Extension. It covers the objects, organization, and methods of procedure. It provides that the county extension agents will be joint representatives of the University of California College of Agriculture and the U. S. Department of Agriculture, and prescribes their several activities, and the way in which their numbers and kinds will be determined.

The salaries of most of the extension agents within the counties are paid jointly by the College of Agriculture and the Federal Department of Agriculture. The salaries of a small proportion of them are paid wholly by the State, through the University. These latter, however, have a Federal appointment which permits the use of the franking permit for transmitting official publications and correspondence.

For each county in which an extension organization is maintained, there is a signed project coöperative between the U. S. Department of Agriculture, the College of Agriculture, and the County Board of Supervisors. This project is signed by the State Director of Extension as representing both the University and the Federal Department, and by the chairman of the County Board. It provides that the farm advisors shall be the leaders of the project, states the object and procedure of the work, and provides that the various extension agents shall be appointed by the University of California and the U. S. Department of Agriculture, working in coöperation.

This project has two important specific provisions, one under organization, and one under financial support. Under organization, provision is made for a county farm bureau, organized around certain local community headquarters, known as Farm Bureau Centers, where the farm advisor or assistant farm advisor is due on regular schedule each month. Provision is made also for a special department, to be known as the Farm Home Department of the County Farm Bureau. The relations of the county extension workers to farmer organizations have been made the subject of careful study by Federal and State extension administrators. Several publications have resulted (6b; 46—30; 47—3).

Under financial support, it is provided that the University of California and the U. S. Department of Agriculture shall jointly pay the entire salaries of the county extension agents and that the Board of Supervisors shall place at the disposition of these other coöperating parties a stated sum to cover the local expenses of the various extension agents, with the further understanding that the distribution of this fund for the different necessary items of expense shall be directed by the State leader, but that the actual disbursement shall be through the regular channels provided for all county funds.

This coöperative agreement does not provide specifically for the furnishing of county headquarters by the Board of Supervisors. Of the forty county headquarters of the Extension Service in California, four are in Federal buildings, fifteen in county buildings, and twenty-one in privately owned buildings. Offices located in Federal and county buildings are not charged for the expense of rental, heating, lighting, or janitor service. Of the twenty-one county offices housed in commercial buildings, in the fiscal year 1930, twelve pay rental for office space to the amount of \$6400, the other nine obtaining their quarters free through the informal coöperation of commercial individuals or organizations. Of the twelve which pay rent, seven pay also for heat and light to the amount of \$537, and eight pay also for janitor service to the amount of \$840 per annum. All these expenses for the maintenance of county offices are borne by the Boards of Supervisors.

Coöperative financial contributions.—Most of the Federal and State funds are invested in the salaries of the technical extension

workers in the counties and at State headquarters. Only 10 to 12 per cent is expended for other purposes, such as travel, equipment, publications, etc. On the other hand, nearly two thirds of the county funds are expended for operating expenses of the various county agents, and the remainder is applied to the salaries of clerical workers at the county headquarters.

The average annual expenditure of funds from all sources for agricultural extension in California is now \$800,000 or more. Of this total, the Federal government contributes about one fourth, State appropriations account for about one half, while sources within the county furnish the remaining fourth. For the country as a whole, State appropriations average much less than in California, or only about 29 per cent of the total. County appropriations, however, average about one third of the total, or more than in California. Federal appropriations average 38 per cent of the national total, or much more than in the case of California, where State appropriations are unusually large. In the total national extension fund of over \$24,000,000 from all sources, the contribution from private individuals and organizations comprises less than 5 per cent. As the contributions from within the counties constitute about one third of the total fund, the proportion of county funds represented by private contributions is less than 14 per cent.

The amounts contributed by State, county, and local agencies always have greatly exceeded those from Federal sources except in the war year, 1919, when enormous temporary increase of Federal funds was made. In the entire period of seventeen years since the coöperative work began, California has invested about \$8,375,000 in the work, while the U. S. Department of Agriculture has contributed about \$2,350,000. The Federal contributions, therefore, have been about three tenths as large as the State contributions; or, in other words, the State and county together have contributed about three times as much as the Federal agency. The present Federal estimate is that California contributes about \$3.18 for each Federal dollar. The proportion paid from State sources is steadily increasing at the present time, and has been for the last ten years. Owing to wide fluctuations in Federal funds in the early years, however, the percentage for the entire seventeen years is not markedly different from that of the more recent years.

Emergency Coöperative Activities

The coöperative Federal-State Extension Service has a larger part in emergency activities affecting rural areas than any other governmental agency. This follows naturally from the fact of its organization on a Federal, State, and county basis throughout the nation, and from its exceedingly close touch with rural problems both through farmers' associations and through individual families. In short, it is organized for effective personal contact with farmers, farm women, and farm children. Consequently, in the emergencies caused by war, drought, flood, insects, hurricanes, or depression, the extension workers are the first line of defense. For present purposes it is necessary to discuss only wartime emergency coöperation and depression emergency activities.

Wartime emergency activities.—It is possible to do no more than list the various types of activities in which agricultural extension workers were engaged during the World War. Most of these activities were related to the war-time work of the Federal and State agricultural agencies, but there was coöperation with many other Federal and State departments and independent boards and commissions (28:136-46; 35:134-51; 42—1918:336 ff., and 1919:353 ff., and especially 377 ff.).

U. S. Department of Agriculture: County agents, home-demonstration agents, and other extension workers coöperated with virtually all the Bureaus of this Department in one or another of the various activities promoting crop and livestock production and protection, and the economical and efficient handling of our national agricultural enterprise during the war emergency. The classified summaries given below are illustrative.

Crop production and use: Federal-State extension service agents obtained samples of spring wheat, and located and distributed seed corn; determined the condition of the clover-seed crop, the distribution of sweet-clover acreage, the number of farmers raising vetch, and the extent of the pecan crop; determined the quality of wheat and other cereals threshed; obtained crop reports, facilitated wheat marketing, the shipment of potatoes, and the making of potato-flour experiments; promoted the storage of vegetables; helped survey food supplies in homes; helped survey sources of lime and potash, and determined the needs of farmers for nitrate of soda and distributed the material; and aided in a survey of fertilizer prices.

Protection of crops: Agents of agricultural extension made surveys to determine the extent and damage of cereal and potato diseases, and insect pests of crops and crop products; assisted in campaigns to control grain smuts through seed treatment, to reduce grain rust through barberry eradication, and to protect timber through control of pine blister rust; and aided in campaigns for the control of rodents injurious to crops and to stored products.

Animal production and protection: Extension officers assisted in surveys of livestock numbers; in the movement of cattle from drought-stricken areas to States with adequate pasturage; in encouraging the use of national forests for grazing; in obtaining lists of sheep feeders, and of farmers keeping bees; in collecting data on wool marketing, and the prices of wool and hides; in listing cheese factories, and in cottage-cheese campaigns; in locating supplies of hay, and in collecting feed-supply reports; in surveys of contagious diseases of cattle, and in control campaigns for animal parasites, hog cholera, and predatory animals.

Agricultural economics: Extension service agents assisted in obtaining crop and livestock reports; in determining acreages of winter and spring wheat; in making soil-erosion surveys; in determining the dependence of ranchers living near national forests on those forests; in obtaining lists of buyers of farm products and in the survey of retail markets; in determining the financial condition of farmers suffering crop failures and in arranging seed loans to farmers in drought areas; in surveys to determine farm-labor needs and supply, in placing farm help, and in ascertaining the number of farmers in each draft class and the shortage or surplus of labor in such class.

Agricultural engineering: Extension employees assisted also in obtaining information on prices of farm equipment, use of tractors on farms, and increase in use of farm machinery; and in promoting the campaign for a standard width of farm vehicles.

Department of Labor: County agricultural agents assisted the Employment Service, the Children's Bureau, and the Labor Reserve in different ways, with special reference, naturally, to the labor problems of agriculture.

Treasury Department: County agents helped this Department in the liberty loan and war savings stamps campaign, in the organization of farm loan associations by the Farm Loan Bureau, and in the control of influenza by the Public Health Service.

War Department: To this Department service agents gave help in obtaining contracts for growing castor beans, in procuring spruce timber for aircraft production, and in getting labor for camp building; in locating walnut timber, in compiling lists of shoe dealers, in collecting fruit pits for use in making gas masks, and in purchasing animals and fodder for the army; in considering soldiers' furloughs and deferred classification for farmers, in a census of disabled farmers operating farms, and in placing conscientious objectors as farm help.

Federal Trade Commission: For the Commission, county agricultural agents made a survey of farm machinery prices.

Food Administration: To this war agency the Federal-State extension service gave collaboration in obtaining lists of bean growers and grist mills, and data on milk production; in preparing lists of stock feed used by farmers; in taking a hog census; in determining prices of foodstuffs, dairy products, and dairy feed; in stimulating bean production, and in the sale, sampling, and inspection of the crop; in the inspection and grading of wheat; in the food-pledge and food-conservation campaigns and the use of food substitutes.

Fuel Administration: County agricultural agents made surveys of fuel materials and obtained lists of fuel dealers and of public buildings which used coal.

Railroad Administration: County agricultural agents worked hand in hand with the Administration's department of agricultural development.

Red Cross: Extension service agents helped the Red Cross in making a survey of nurses, in campaigns for funds, and in its relief activities.

Council of National Defense: County agricultural agents aided notably in the Council's thrift and conservation campaigns; in its survey of motor-transportation routes; in obtaining data on wool prices; in the distribution of farm machinery; in grain conservation through making report of owners of threshing outfits and through assisting in the routing of outfits, in establishing fair service prices, and in inspection of threshings.

Depression emergency activities.—The Agricultural Adjustment Administration was created early in 1933 to help solve the critical problems of American agriculture that developed with the end of the World War. The success of the necessary measures depended and still depends on the farmer's coöperation. As noted heretofore, the Extension Service is the only public agency so organized and distributed as to be able to make contacts and carry a national plan to the farms. The largest single activity was the series of campaigns to reduce surplus production of such staples as cotton, wheat, corn, hogs, and tobacco. Within the first year these campaigns required the obtaining of some 5,000,000 signatures, a huge task which only the extension workers could accomplish. Other similar activities covered canning crops and the dairy industry. The home-demonstration agents also had a large share in the agricultural program as it affected the farm home.

Publication of Results

The Federal Department of Agriculture is designated by law as the approving and coördinating agency for the extension activities of the several States. One of the chief informational features of this work is the assembling of extension data from all the States

and its publication for the use of all Federal and State agencies. The annual reports and compilation of statistics already have been described. Other publications deserve mention here. The three major groups of activities in the extension program are those conducted respectively by the county agents, the home-demonstration agents, and the leaders in club work with boys and girls.

The status and results of county-agent work were published annually from 1918 to 1924 inclusive, the last circular being a ten-year summary (46—37, 106, 179, 244, 316, and 347; 47—59). In the first four years these publications covered only the northern and western States, but thereafter they covered the entire country. The beginning of home-demonstration work was preceded by a survey of the social and labor, domestic, educational, and economic needs of farm women, conducted by the Federal Department of Agriculture (50—103, 104, 105, 106). This was followed by the publication of a series of annual reports showing status and results of home-demonstration work in the northern and western States from 1919 to 1921 inclusive (46—141, 178, 285), and in the entire country from 1922 to 1924 inclusive, the last named comprising a ten-year summary (45—43; 46—314 and 399). A similar ten-year review of home-management extension likewise was published (45—17).

The results of boys' and girls' club work were published in the same way as those for county-agent and home-demonstration work. The organization and results in the northern and western States were published for the years 1918 to 1921 inclusive (46—66, 152, 192, 255). The results of these activities for the entire country were published for the years 1922 to 1924 inclusive, publication for the latter year comprising the ten-year summary (46—312 and 348; 47—85). Extension work among negroes was published for the years from 1920 to 1923 (46—190 and 355).

In 1922 or 1923, or both, the extension activities were published for several subject-matter topics, such as agronomy, farm management, food and nutrition, agricultural engineering, etc. (46—270, 302, 329, 343, 344, 346, 349). Ten years of agronomy extension from 1915 to 1924, inclusive, were summarized (45—22), as were also the activities in farm-management extension for the same period (45—30). Extension work in coöperative marketing, as promoted by the Federal Bureau of Agricultural Economics and

the former Federal Farm Board, jointly with Federal and State extension agencies, was reviewed and published in 1931 by the U. S. Department of Agriculture (45—159).

Numerous studies of the relative effectiveness and cost of different extension methods in reaching the people of the rural areas have been made coöperatively by Federal and State agencies and published by the Federal agency (43—1384; 44—106 and 125).

All publications of the Federal Department of Agriculture dealing with the different phases of collaborative agricultural extension, as discussed above, bear a printed statement of the coöperative relations between the Department and the State Colleges of Agriculture. This statement is displayed, partly to make the publications eligible for mailing without postage under the terms of the Smith-Lever Act, and partly as a public recognition of the coöperative character of the work.

The extension services of the several States publish abundantly for the information of their constituencies. These publications usually take the form of an annual report and of numerous issues in a circular series. Ordinarily no coöperation is involved in the actual preparation and publishing of the material. In order to make the publications eligible for sending through the mail without payment of postage, however, each bears on the cover, either inside or outside, the words (or their equivalent), "Coöperative Extension Work in Agriculture and Home Economics, College of Agriculture, University of [California], and the United States Department of Agriculture coöperating. Distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914."

The publications listed in the Literature Cited at the end of this chapter which have been cited in this section on Agricultural Extension are Nos. 2, 6b, 11, 18, 20, 22, 28, 29, 35, 42, 43, 45, 46, 47, 48, 50, 52, 54, 59, 62, 64, 66, 76, 77, 78, 79, 85, 86, 94, 95.

5. INFORMATION SERVICES

AGRICULTURAL EDUCATION is carried on by many and diverse means. Three major methods, resident teaching, research and its publication, and extension by demonstration, already have been discussed. There remain to be considered the several services which for convenience may be grouped under the broad title of information serv-

ices. These in turn may be divided into such groups as Library services, Literature indexes and bibliographies, Visual Education services (including lantern slides, motion pictures, and exhibits), Press News services, and Radio News services. Some of these date well back into the last century, while others are of recent development and of rapid and enormous expansion in the past few years. In 1932 a summarized discussion of State and Federal coöperation in informational campaigns was given before the Association of Agricultural College Editors and afterwards published by the Extension Service of the U. S. Department of Agriculture (77—175).

LIBRARY SERVICES

Under this title are grouped two different activities. The first covers book depositories, exchanges, and loans. The second comprises the furnishing of indexes and bibliographies of literature.

Book Depositories, Exchanges, and Loans

Various international, Federal, and State agencies are brought into relations by this group of library services.

Libraries designated as Government depositories.—The distribution of Government publications to university and college libraries was first authorized in 1813, but it was just one hundred years later, in 1913, that the designation of government depository was made permanent during the existence of a library. In 1858 it was provided that each representative and delegate in Congress might designate one library in his district as a depository to receive congressional documents, which then comprised virtually the only government publications. In 1859 the privilege was extended to senators also, although they had no specific districts. In 1895, congressional enactment added the State and Territorial libraries and the then existing eight executive-department libraries, and the sending of the publications of the executive departments was provided for. The libraries of the land-grant colleges and universities were added by statute in 1907.

The Superintendent of Documents (92) of the U. S. Government Printing Office (90) is charged with the administration of this distribution of Federal publications to the statutory and designated depository libraries (91). As these include the State library, the

library of the Land-Grant institution, and at least one other library in each congressional district, the effect is to make Federal publications available to any citizen at no great distance from his home. The shifting of the boundaries of congressional districts with succeeding decennial reapportionments has caused some shifting of designated libraries.

In 1913, as noted above, the designation of a given library as a depository was made permanent during its existence, which obviated confusion resulting from change of congressional districts. In 1922 the libraries were permitted to choose the classes of documents they wished to receive. Previously, all Federal publications had been sent automatically to each statutory and designated depository. While theoretically the recipients were obligated to care for all material received, this was not only a physical impossibility in many cases, but was also quite unnecessary and even undesirable. Such libraries were put to the expense of returning or otherwise disposing of the publication which they could not catalog and shelve, while the government was put to the double expense of printing them in the first place, and of receiving and redistributing returned material.

With the enactment of the new law in 1922, only 60 out of 446 government depositories elected to continue to take all government publications. Of the remaining 386, there were 228 which continued to receive more than half the numbers issued. The library of the University of California makes request for substantially all the Federal publications issued, the chief exceptions being certain classes of hearings before committees of Congress. It is significant also that after the enactment permitting them to choose such publications as they desired, several additional libraries made request to be designated as depositories. A total of 661 might be included in the combined statutory and designated lists under existing law.

International Exchange Service.—The United States section of the International Exchange Service operates under the direction of the Smithsonian Institution (31; 32). The Service receives publications from learned bodies, scientific and literary societies, and institutions and individuals, in the United States, for transmission to similar institutions and organizations abroad. It also receives similar consignments of publications from abroad for distribu-

tion to institutions, organizations, and individuals in this country. Transportation of publications from domestic sources and from foreign sources to the Service must be prepaid. Packing and transportation charges from Washington to destination, either domestic or foreign, are borne by the Service, and not by the recipients.

The system for the exchange of scientific literature was established early in the history of the Smithsonian Institution. It developed steadily, soon including the exchange of parliamentary (congressional) documents as well. In the five-year period, 1850-54, the average annual weight of packages handled was 9200 pounds. In the five-year period 1925-29, the average annual weight had risen to 566,500 pounds. For the fiscal year 1929, the total weight handled was 621,373 pounds, representing 620,485 packages, of which 471,885 pounds, or 562,192 packages, were sent abroad.

The rapid increase in exchanges began about 1875. In 1889, or nearly forty-five years ago, about one half of the packages were governmental exchanges. By 1929 about three fourths of the packages, but less than three fifths of the weights, represented governmental exchanges. Material was sent to about fifty countries.

Many State agencies are eligible to receive this service in the exchange of their publications. The major groups of such agencies are listed below :

1. State executives, departments, boards, and commissions, the legislature, and the judiciary;
2. The State university and other State-supported educational institutions;
3. State official or semiofficial scientific and technical societies, such as the State Geological Society, Academy of Science, Agricultural Society, Botanical Society, Historical Society, Horticultural Society, etc.;
4. Unofficial but noncommercial technical organizations;
5. Individuals wishing technical and scientific exchanges.

The total Federal appropriation for 1929, including salaries, was about \$50,000 plus about \$8000 from endowment.

Interlibrary book loans.—There is a growing service which covers the loans of rare books for workers served by libraries not owning them. Because of age and size, certain Federal libraries

can make widely available many early works not found in newer libraries. The library of the Department of Agriculture (82) is in a position to render large service of this sort (6a; 52—1897:220-24 and 1927:423-24). Within the several States there is a considerable interchange of library possessions. On a smaller scale there is borrowing from State libraries by Federal units. There also is exchange and loaning of manuscript translations of important papers in foreign languages. Finally, researchers from one institution are gladly provided with library facilities when temporarily located at another institution.

In Washington, D. C., besides the Library of Congress, there are numerous technical libraries belonging to the executive departments, to their component bureaus, and to the many independent establishments. Books from most of these libraries may be obtained by technical and professional workers in the Federal government or in the States, through their institutional libraries. The Library of Congress makes special effort to be a service institution, operating under definite regulations for the benefit of the country as a whole (40; 93). In this way rare books are made available to workers who otherwise could not have access to them except by a visit to the owning library in Washington. While the total volume of loans of this character is not large, the nature of the books thus loaned gives to the service a value greatly out of proportion to the number of the books. In the ten years from 1914 to 1923, inclusive, the U. S. Department of Agriculture library loaned to California libraries a total of 288 books, or an average of 29 books annually, the actual number varying from 16 to 50 in the different years.

On the other hand, the library of the U. S. Department of Agriculture and the special libraries of the component units are used increasingly by visiting technical workers from the State colleges and experiment stations. During official research, they are given working space within the library itself, or within one of the subject-matter divisions to which their work relates and where usually they are well acquainted. Oftentimes they are furnished some clerical assistance, also, by these subject-matter units.

For the use of its own workers, the U. S. Department of Agriculture, and presumably other Federal agencies also, is obliged to make translations of articles printed in foreign languages not usu-

ally or easily read by American workers. This applies especially to technical publications in Chinese, Japanese, Russian, Polish, and Czecho-Slovakian. Sometimes highly technical articles are translated also from Italian or the Scandinavian languages. Ordinarily, these translations are typewritten in several copies, at least one of which will be deposited in the library of the Bureau concerned, and another in the library of the Department, besides the copies remaining in the Division of origin. These translated papers are announced in the bibliographic lists issued by the various units, and their existence thus is made known to workers throughout the country. Many requests for the loan of Federal translations are received from State workers, and granted whenever possible.

Literature Indexes and Bibliographies

With the growing volume of material on agriculture, indexes to published literature and bibliographies in selected fields are of growing importance. International and intranational relations have developed. Apart from the services discussed below, the reader is reminded of the kindred services discussed under the subheading, Coöperative Publication Services, in the section on Agricultural Experimentation and Research, to be found earlier in this chapter.

International Catalogue of Scientific Literature.—This activity was organized to index and classify the titles of all scientific papers published in the United States, through an American "Regional Bureau" established under the auspices of the Smithsonian Institutions, the same to form a part of the International Catalogue of Scientific Literature issued by the Central Bureau in London.

The idea was first suggested by Professor Henry of the Smithsonian Institution in 1855, at a meeting of the British Association for the Advancement of Science. An international conference was held in London in 1896. The International Catalogue dates from 1901, replacing the Catalogue issued by the Royal Society. The Catalogue was published annually in 17 volumes for each of 14 years, indexing the literature of 1901 to 1914, publication of which was finished in 1922. The Catalogue, therefore, comprises 238 volumes, together with several extra volumes containing lists of journals and of classification schedules (31; 32).

Publication was suspended in 1922, owing to lack of funds, but the United States Regional Bureau, in agreement with other regional bureaus, has continued to keep record of current scientific periodicals, etc., and to prepare data for a revised list of journals, in order that actual indexing may be resumed when reorganization becomes possible.

The Central Bureau in London derived its sole support from sales of the annual volumes at about \$85.00 per set, 1000 sets being printed. The regional bureaus were supported in most cases by direct government grants from the thirty-three countries cooperating.

Since the discontinuance of the International Catalogue, the United States Regional Bureau has operated on a greatly reduced basis, the appropriation for 1929 being \$7460, and expenditures \$5060. To reorganize the service, it is estimated that a central printing plant costing \$30,000 would be required and that after the first year \$35,000 per year would be sufficient for the operation of the Central Bureau, a cost that would be more than met by the sales of current and back volumes.

Bibliographies of selected subjects.—Both the research agencies and the total volume of research publications in agriculture have been enormously increased in the last quarter century. The rapidly growing number of publications appearing from year to year makes increasingly difficult the task of the worker who must review the literature of his subject. The natural result has been a swift increase in the number of bibliographic contributions on many subjects and from many sources. There never was a time when these aids to the research worker were so numerous and complete, or when the citations were so commonly accompanied by abstracts. These bibliographic contributions are of value not only to the investigators themselves, but to extension workers also, and to the increasing number of popular writers who provide the various types of information service under discussion. Naturally, most of these appear from Federal sources.

The Library of the United States Department of Agriculture published in its Bulletin series (83), between 1894 and 1912, several bibliographies or lists of publications. Each had to do with the literature of a single subject, e.g., sugarbeets (83—16), poultry

(83—18), forestry (83—24 and 76), irrigation and drainage (83—41), botany (83—42), and entomology (83—55). In 1919 it began the publication (mimeographed) of a series of *Bibliographic Contributions* (84). These are subject-matter bibliographies, running often to hundreds of pages and thousands of entries. Not only are the subjects exceedingly diverse, but the source material varies greatly. One may be concerned with the literature of a given subject published by the State stations, whereas another covers the same field as presented by Federal publications. Still others present the literature of a subject as gathered from all available sources. In each of them, the subject covered is classified and subclassified with a detail very helpful to the worker. More recently, a discussion of bibliographical aids was issued (52—1928:156—59).

In the relatively new territory of agricultural economics there is a perfect flood of literature arising in this country and abroad. The library of the United States Bureau of Agricultural Economics is performing a valuable service in its subject-matter series of bibliographies appearing under the title, *Agricultural Economics Bibliography* (57). To date, some forty numbers have appeared, in mimeographed form, some of them running to more than a hundred pages, and No. 31, dealing with State sources of agricultural statistics in California, contains 1400 pages in the four parts already issued. These are not mere bibliographies, for each entry is accompanied by an abstract of the publication cited. Many of these abstracts are taken from the *Experiment Station Record* or other journals, but some are original. The entries are arranged alphabetically by authors, and each issue is provided with a detailed cross-reference index.

In addition to the above-mentioned series, the Federal Bureau of Agricultural Economics issues a mimeographed monthly under the title, *Agricultural Economics Literature*, which is now in its eighth volume (58). This contains a variety of bibliographic material, including signed reviews of important papers and books, abstracts of notable current books and documents, lists of recent bibliographies and translations, selected lists of recent reviews, lists of current papers from Federal and State sources, and, finally, abstracts of articles in current periodicals, classified by subject and source.

Besides these mimeographed bibliographic and abstracting series, there are many printed bulletins devoted to bibliographies on numerous and varied subjects in this field. The Federal Department of Agriculture issues such publications from time to time, and others appear from other Federal sources (47—11 and 35; 48—78, 84, and 123). On a much smaller scale, State agencies also produce agricultural bibliographies.

VISUAL EDUCATION SERVICES

The three common present-day forms of visual education in agriculture are exhibitions, lantern slides, and motion pictures. In the form of exhibits, at shows, fairs, and expositions, such education dates back to Colonial days and developed very rapidly in the early period of our national existence. The other forms, of course, are of comparatively recent origin.

Exhibition Service

The Federal Department of Agriculture has prepared exhibits illustrating different phases of its work and displayed them at various expositions (66—109) for some three-quarters of a century. During most of this period, however, it had no permanent organization for this purpose. Each Bureau or Division prepared what it considered suitable or possible for each succeeding occasion. There was no uniformity of plan or continuity of effort. As the Department grew in size and complexity, and the number of opportunities and requests for the display of exhibit material increased, it became necessary to coördinate and organize the scattered efforts.

The Office of Exhibits (42; 61), established in 1913 as a separate unit under the Office of the Secretary, has been a Division of the Extension Service (76; 79) since the creation of that unit in 1923. It prepares material representing the varied activities of the Department for exhibit and demonstration at State, interstate or regional, national, and international fairs and expositions. It formerly participated also in county and sectional fairs, but the demands on its funds and personnel now have become so large that it can cover only the larger and more important exhibitions (46—385; 52—1928:269—73, 1930:236—39, and 1931:216—18).

While the character and scope of the exhibits tend to increase in

diversity, there has been likewise a tendency towards standardizing the size and space requirements of units. This permits ready allocation of units to space provided by fair associations, and also permits the ready substitution of one unit for another in any plan of exhibit. In the same way, much attention is given to mechanical construction, and to devices which permit assembling, installation, removing, and packing of exhibits with the least labor and technical supervision, thus reducing to a minimum the expense of handling. So far as possible, exhibits are routed on a circuit which permits the largest possible presentation of the material in the least time and with the least expense for transportation between exhibit points, and therefore with the fewest possible returns of the material to storage near Washington, D. C. From the same motives of efficiency and economy, shipments are made in carload lots whenever possible.

To govern its participation in fairs, the Department has worked out a definite plan of coöperation with State Fair Associations and similar exhibit organizations. Under this agreement the Department provides the exhibit material and the personnel necessary for its installation and demonstration. The fair associations provide the cost of transportation of exhibit material by a cash deposit made in advance. They provide also exposition space, storage for the containers, labor and drayage for unloading and reloading cars, common labor for unpacking, installing, dismantling, and repacking exhibits, and janitor, custodial, electrical, and other services necessary to a suitable display. Specially devised electrical apparatus greatly reduces the time and expense of making power and light installations on government exhibits. Much care is given also to routing exhibits on short-haul circuits, thus reducing the cost to each association in the circuit. The total cost, prorated to all the associations of a given circuit, must be covered by cash deposits in advance.

Many requests for assistance in finding sources of exhibit material, in devising methods for exhibit presentation, and for planning expositions are received annually by the Department and complied with so far as possible. Requests are received annually also from several of the State Colleges of Agriculture for the preparation of complete exhibits of Department material to be used in

the college educational program. Unfortunately, legislative authority for such coöperation does not exist. On the other hand, assistance in obtaining exhibit materials is received by the Division of Exhibits from various State agencies from time to time.

In order to systematize the work in the western States and to enable fuller coöperation with western agencies, a western fair service was established by the Department in 1924. Since that time, exhibits have been placed coöperatively at the following expositions in California. This list will show the constituencies served in a single representative State.

1924	League of California Municipalities.....	Coronado
	Fresno District Fair.....	Fresno
	Pacific Slope Dairy Show.....	Oakland
	Los Angeles County Fair.....	Pomona
	California State Fair.....	Sacramento
1925	Fresno District Fair.....	Fresno
	U. S. Chamber of Commerce, Western Division...	Los Angeles
	Southern California Fair.....	Riverside
	California State Fair.....	Sacramento
	National Orange Show.....	San Bernardino
	Ventura County Fair.....	Ventura
1926	National Orange Show.....	San Bernardino
	All-Western Road Show.....	San Francisco
	California State Fair.....	Sacramento
1927	All-Western Road Show.....	San Francisco
1928	California Dairy Show.....	Oakland
	Western Road and Equipment Exposition.....	Los Angeles
1929	Pacific Southwest Exposition.....	Long Beach
1930	Sixth Annual Food and Household Show.....	Los Angeles

Total appropriations for the Federal Division of Exhibits were \$120,000 in fiscal year 1930. Organizations desiring exhibits deposited approximately \$10,000 additional to cover the prorated cost of transportation of exhibits to their localities.

Lantern Slide Service

The Office of Coöperative Extension Work, Extension Service, U. S. Department of Agriculture, in coöperation with the various subject-matter Bureaus of the Department, and with some State agencies, has prepared about 170 series of lantern slides (48—72). These cover a wide range of agricultural topics, including the con-

servation of agricultural resources, such as soil, forests, water, etc. Many of these series are available not only as glass slides but as film strips also. In addition, the U. S. Forest Service has about 45 series of colored slides on various forest topics. Each series of slides or film strips is accompanied by full descriptive legends, and most of them, also, by suggestive notes to help the user.

While these series of lantern slides have been prepared especially for the use of extension workers, they may be obtained by other agencies through the State Director of Agricultural Extension. No charge is made for the slides, but the borrower is required to pay transportation charges both ways and to repay the cost of any slides injured or destroyed, either in use or in return transit. The same rules apply also to loans of Forest Service slides.

Arrangements have been made whereby State workers may purchase series of these slides or film strips at relatively low prices governed by annual contract after competitive bids have been obtained by the Department. The name of the contracting firm and a blank for making orders may be had from the Office of Coöperative Extension Work, from whom approval of such purchase must be obtained. In a similar way, State workers may have their own material made up into slides or film strips by a firm operating for the Federal Department under contract prices. The name of this contracting firm, also, may be had from the Office of Coöperative Extension Work.

A single series of lantern slides may be applicable to conditions over a whole group of States. When a Federal agency, therefore, prepares desirable slides and makes them available at only the cost of transportation and breakage, there results a great saving to the States. Within a single State, a series of its own making probably would lie idle most of the time, whereas a Federal series is likely to be used almost continuously through consecutive loanings to several different States.

Motion Picture Service

As a part of its procedure in extending agricultural information and building up sentiment in favor of conservation, the U. S. Department of Agriculture has been providing, in the last fifteen years or more, an increasing supply of motion-picture films. The work is done by the Motion Picture Laboratory, a Division of the

Extension Service (76; 79; 86). The number of subjects covered has grown from about 160 in 1922 to 250 in 1930, the number of copies from about 1000 to about 2000, and the number of reels from something more than 1000 to about 3000. In the same period the annual shipments have increased from about 2000 reels to more than 11,000 in 1929 and about 10,000 in 1930. The falling off in this latter year was due to a decreasing demand for pictures without sound accompaniment, and an increasing demand for talking pictures which the Department was not able to supply. Approximately twenty new films are made each year, with an average of about thirty reels. In addition, older films are revised. Some out-of-date films are withdrawn from circulation each year, so that the net increase in number of subjects is about ten annually. Sales of prints of these films vary from 300 to 400 annually. Since 1920, successive lists of available films have been issued at intervals (46—114 and 233; 47—27 and 86; 48—91, 152, and 288).

The films made by the U. S. Department of Agriculture depict primarily its various activities in the field. They are used commonly by members of the Department staff in illustrating addresses before both technical and popular audiences (52—1926:534—37, and 1928:465—67). They are used commonly also at fairs and expositions, both at home and abroad. As the Department's opportunities for using motion pictures naturally are somewhat limited, it takes full advantage of the immensely wider circulation afforded by loaning films to State agricultural and educational agencies and to private organizations and individuals.

In the early days of the industry, most films were but one reel in length. In recent years the length has been gradually increasing, until three-reel, four-reel, and even five-reel films now are being made. The sudden advent and widespread use of talking pictures has caused an unexpected change in the industry. This is shown by a falling off in demand for the silent pictures, and consequently the Department is now experimenting in talking pictures. All straight educational films are made so that sound easily may be synchronized with the film. The talking picture is so much more expensive than the silent film that it will not be possible for the Department to enter largely into the making of talking pictures until its appropriations are materially increased.

In the making of its films the Department has some informal coöperation with State agricultural and conservational agencies. This consists in assistance from State personnel in locating the desired subjects and in furnishing some of the transportation for the film-making staff. Formal arrangements recently have been made with certain States looking toward complete coöperation in financing the making of films of special importance to these and adjacent States.

The principal coöperation at present lies in the loaning of Department films to State and private agencies without charge. The borrower pays transportation charges to and from Washington, D. C. The loan period may be short or long, depending on the use which the borrowing agency proposes to make of the film. As the Department carries in stock several copies of each film, loans may be made to several agencies at the same time. In spite of its supply of about 2000 copies of its 250 subjects, many requests for loans must be declined each year for lack of a sufficient number of copies. About 3500 shipments of loan films are made annually in recent years, each shipment comprising an average of two subjects in scope and three reels in number, or a total of 10,000 to 11,000 reels annually.

Many agencies desiring permanent use of films purchase them instead of borrowing. As the average cost is only about \$35.00 per reel, no very great outlay is required. The sales of prints have varied from 200 to more than 400 annually in recent years, an increasing proportion consisting of more than one reel per film.

Reports made by coöperating agencies on the number of persons viewing the borrowed films indicate that these are seen annually by about 5,000,000. It is estimated that an equal number view the Department films sold to State and private agencies. This would give a total annual audience of more than 10,000,000 for the films owned or sold by the Federal Department of Agriculture. In 1926 films were loaned to seven State universities and colleges of agriculture, to two State departments of agriculture, to two school boards, and to one State health commissioner. Two years later, in 1928, the number of State agencies requesting loans of films had about doubled. In 1928 a total of 128 films was loaned to agencies in California for a total of 3374 days. Of these films, extension

workers borrowed 45 and other general public agencies borrowed 83.

The direct Federal appropriation for motion pictures in 1930 was \$63,000, to which may be added some \$15,000 expended by the various subject-matter bureaus in helping to defray the expenses of motion pictures in their respective fields. In addition, sums were made available by appropriations for films for special international scientific congresses and expositions abroad.

NEWS SERVICES

While all publication may be regarded as news service, the term is restricted here to the ordinary sense of timely but more or less ephemeral matter put out at regular intervals for immediate use. In this sense its principal lines are the press service, the market-news service, and the weather forecasting service. The press service supplies a wide range of agricultural matter to dailies and weeklies, while the other two services furnish highly specialized but popular material to the same agencies of distribution. Federal and State offices, both in coöperation and independently, utilize news services to an ever increasing extent.

Press Service

The Federal preparation and distribution of what is here called press service material is the function of a unit called the Press Service, in the Office of Information (81) of the United States Department of Agriculture. These activities cover both agriculture and natural resources in so far as these last (such as soil, water, forests, game, fur animals, etc.) concern the U. S. Department of Agriculture. The Press Service provides popular information on the results of Departmental research and extension, in three general series of publications, as follows:

Press releases (mimeographed).—These are abstracts of addresses on agricultural subjects scheduled by Department personnel, or of forthcoming publications. They are mailed in advance of delivery or publication, and bear a release date after which they may be used. Each abstract opens with a few short summary paragraphs and continues with a longer discussion, thus giving users some choice of length without rewriting. They are widely distrib-

uted to the press, and to organizations, institutions, and individuals for information and use.

Page, line, and paragraph (multigraphed).—These are collections of short paragraphs on timely agricultural topics, sent out at short intervals for general information, for suggestive use by writers, and for use as fillers by the press. The items range from two to ten or fifteen lines in length.

Clip sheet (printed).—Up-to-date reading matter on timely agricultural topics, arranged in single standard column for ready use by the press, especially the weekly and agricultural papers.

There is widespread coöperation with State agencies in the distribution of press material. California is an illustration. Some twenty official units or agencies in the State are supplied with one or more of the different forms of press material, as are also the representatives of various Federal agencies in the State. The State agencies include units of the University of California and its agricultural experiment station; various departments of the State government and their component bureaus at Sacramento, and some of the independent boards and commissions. Some of their branches are included also.

Press matter of one or more of the kinds mentioned is sent also to numerous California commercial and associational agencies. These include more than a hundred daily newspapers, about a hundred small-town weeklies and semiweeklies, some seven farm papers, several farm-paper correspondents and numerous free-lance writers, commodity and subject-matter journals covering a wide range of agricultural commodities and subjects and related commercial industries (as well as journals concerned with conservation and nature), chambers of commerce and other business organizations, and agricultural and conservational organizations.

During emergency campaigns, such as those to eradicate diseases or insects, or to relieve drought-caused distress, in either a State or group of States, the Office of Information of the Federal Department causes the creation of special mailing lists for the occasion, including publications, organizations, and individuals.

The wide distribution of information on results of the Department's research to commercial organizations and journals only indirectly connected with agriculture is very important because the

products of agriculture are the raw materials of many other industries and a sympathetic understanding of the problems of agriculture, and an intelligent appreciation of its accomplishments, on the part of these other industries, as well as by the general population, is very highly desirable. Journals in the following subject-matter groups are supplied :

Agricultural Engineering	Farm implements	Packing
Automobiles	Forestry	Paper and pulp
Bee culture	Fruits	Pet stock
Building and construction	Grain trade	Poultry
Canning	Grocery trade	Radio
Clothing trade	Home economics	Real estate
Commerce	Hunting and fishing	Recreation
Confectionery	Hygiene	Roadmaking
Coöperation	Leather	Science
Cotton	Livestock	Seafood
Country life	Medicine	Truck crops
Dairying	Motion pictures	Veterinary
Drygoods	Municipal affairs	Woman's wear
Education	Nuts	Wool

The State universities and colleges of agriculture maintain extensive press services of their own, aside from their coöperation with the Federal agencies. Many of them, like the University of California, prepare and distribute a weekly clip-sheet which combines most or all of the features of the three kinds of Federal news issues described above. Any such program of publicity involves wide coöperation within its own State institution. To a relatively limited extent, State departments of agriculture and State conservation units follow the same procedure.

Market News Service

With the steadily increasing importance of the economic side of agriculture, there arose an insistent demand for market news gathered by noncommercial agencies. This demand led to the establishment of the Federal-State market news service in 1915, on a small scale (52—1919:127-46).

The service supplies information on the supply of, and demand for, the various agricultural commodities and their products. It covers also the wholesale market conditions and prices current for

agricultural commodities and products at local markets, and at the larger eastern consuming centers. All this information is made available to producers, to those engaged in the processing and in the wholesale and retail distribution of the commodities and their products, and to other interested persons (55).

From the Federal standpoint, the work covers five major groups of agricultural commodities, represented by five separate divisions of the Federal Bureau of Agricultural Economics, namely: Cotton Marketing; Livestock, Meats, Wool; Dairy and Poultry Products; Fruit and Vegetables; and Hay, Feed, and Seed. Within the several States the work centers in the marketing unit, usually of the State Department of Agriculture. In California, for instance, the coöperation is with the Division of Markets of the State Department of Agriculture (8). From about 1921 to 1924 these services were begun and developed on an increasing scale in California. The information is obtained and disseminated at both Los Angeles and San Francisco. For the work with fruits and vegetables, seasonal field offices are maintained also at Brawley in the Imperial Valley, and at Fresno.

Much of this market information is distributed daily, but also weekly, monthly, seasonal, and annual summaries of data are prepared. Much of the work, naturally, consists in a research and statistical service under agricultural economics, as related to the various classes of commodities and products named. It is impossible to separate the function of a daily market news service completely from the function of a statistical research service. The major treatment of these activities, therefore, will be given under the chapter on Agricultural Economics. Only the purely temporary market-news phases are presented here in this section on Information Services, of the chapter on Agricultural Education.

The daily and weekly news service is published in the form of news releases issued to mailing lists from the State offices, and also to commercial wire companies, to press associations, and directly to metropolitan and rural newspapers and to certain trade and agricultural publications. The reports also are released in part on local bulletin boards, transmitted on certain circuits of a leased wire system, and released by radio through various broadcasting stations in a given State and elsewhere.

The service has made it possible for all interested persons to keep up promptly and accurately, through an unbiased coöperating national and State market-news agency aided by numerous collaborating commercial agencies, with essential current and historical information pertaining to the agricultural industries. It covers reports on production, storage holdings, consumption, distribution, local and national market movements, and market conditions and prices, as all this relates not only to any State but also to the country as a whole. Such service is regarded as of prime economic importance to those actively engaged in producing and marketing seasonal and often perishable agricultural products, and to those engaged also in the processing and the commercial handling of these commodities and their products.

This entire series of activities is carried on under formal written agreements between the U. S. Department of Agriculture and a given State department of agriculture, specifying the nature of the information to be obtained and the division of expenditures between the two coöperating agencies. These agreements are renewable annually, as are also the budgets thereunder.

Crop and Livestock News Service

In this activity, the Division of Crop and Livestock Estimates, in the U. S. Bureau of Agricultural Economics, coöperates with the State marketing agencies, usually in the State department of agriculture. The two agencies in coöperation collect information, directly and through numerous voluntary observers, and make estimates on the acreage of various crops and the numbers of various livestock, estimates on the condition and probable outturn of crops at monthly intervals throughout their growing season, and make forecasts of production and of quantities (or numbers) and qualities available for market. The work is conducted under a formal written agreement between the two coöperating agencies, which specifies the principles involved, the general procedure thereunder, and the general division of expenses to be incurred annually.

As with the Market News Service, it is impossible to delimit the temporary news features of this work from the more permanent statistical research involved. The proportion which has temporary news value is much smaller in respect of the crop and livestock

reporting service than in respect of the commodity market-news service. The major treatment, therefore, will be given under Agricultural Economics. In general, this service supplements the other by showing actual and relative basis of supply, with recurring estimates of quantity and quality. It is made available to the press and to interested agricultural and commercial organizations and agencies at certain specified times and places.

Weather Forecasting Service

The Weather Bureau of the U. S. Department of Agriculture has many and varied functions, some of which may properly be classified as belonging to this news service, but many of which belong clearly under research and statistics. No sharp line can be drawn between them, any more than in the work of the Bureau of Agricultural Economics. The daily weather forecasts, storm warnings, flood warnings, and fire-probability forecasts, all are parts of a news service. For a full discussion and list of literature cited, the reader is referred to the chapter on Climate in Volume 1.

From some 2000 well equipped weather stations in the United States, Alaska, Puerto Rico, and Hawaii, observations are made regularly at 8 A. M. and 8 P. M. The facts observed are telegraphed immediately in code to the five district forecasting centers in this country, including Washington, D. C., and San Francisco, California. These reports include temperature, atmospheric pressure, humidity, precipitation, direction and velocity of the wind, character, quantity, and movements of the clouds, general state of the weather, and the maximum and minimum temperatures since the last observation. Special phenomena also are noted, such as frosts, storms, and marked changes in conditions. From these accumulated reports, the district forecaster makes up the forecast for his district twice daily.

The morning forecasts are given to the evening papers, are displayed by means of temperature and weather flags, and are printed on weather maps, bulletins, and cards to be posted in public places, especially in post offices, hotels, office buildings, stores, and railway stations. They also are telegraphed to about 1600 principal points for further dissemination by telegraph, telephone, wireless, and the post. The evening forecasts are distributed chiefly through the

various press associations for publication in the morning papers.

Daily forecasts, also, are made by most of the local official observers, to cover a radius of about twenty miles from the observing station. They make known the probable weather, temperature, and wind. During the winter months, they forecast the probable minimum temperature also.

Special warnings are given of the approach of hurricanes, blizzards, cold waves, heavy snows, frosts, and floods, all of which may cause great injury to agriculture. Frost warnings in the fruit and truck-crop districts enable growers to protect orchards and other tender crops by smudging. Shippers' forecasts enable the shipper of perishables to know in advance what conditions confront him. Special forecasts are made also for farmers who must engage in seasonal operations greatly influenced by weather conditions, such as harvesting hay and grain, spraying crops to protect them from insects and fungi, and other particular agricultural operations. Another special service is the "fire-weather" warnings which notify Federal and State forest officials, and the public in general, that conditions are such as to make forest fires probable and likewise very difficult to control.

Besides official coöperation through the State Departments of Agriculture in maintaining the regular Federal-State Weather Reporting Service, State agencies render the fullest coöperation in distributing information regarding all emergency conditions, such as probable frosts, floods, storms, and forest fires which may occasion great losses to agriculture and natural resources unless advance notice is prompt and widespread.

RADIO NEWS SERVICES

With the development of the radio industry, the United States Department of Agriculture, as well as many of the State Colleges of Agriculture, took steps to utilize this new method of disseminating agricultural information. The Federal Department possesses no broadcasting stations of its own. Some of the agricultural colleges, however, own stations, while others have direct coöperative relations with commercial stations in near-by cities.

Radio serves the Department and the State agencies in two distinct ways. It is an effective means of making the permanent rec-

ommendations on improved practices in farming and home-making both vivid and understandable to a nation-wide constituency (52—1928:514—19, and 1930:442—43). These recommendations of improved practices make up the bulk of the syndicated programs (49). It also is a ready instrument for getting rush or emergency information into millions of homes in city and country alike. This emergency type of news is carried most abundantly in the network programs (49).

The chief Federal agency involved in this activity is the Radio Service of the Office of Information (81) in the U. S. Department of Agriculture. The former Federal Farm Board also had a regular part. The principal State agricultural agencies are the Federal-State Coöperative Agricultural Extension Service at the State Colleges of Agriculture, and the bureaus of markets or other marketing units of the State Departments of Agriculture. The State Departments of Natural Resources, or similar State agencies, also coöperate with information regarding the relation of wild life to agriculture.

Syndicated Programs

The first contribution of the Federal Department lay in the field of the syndicated program. This consisted of brief discussions of a series of timely topics suited for use in each of five large regions into which the entire United States was divided. These topics varied with the character of the agriculture and the progress of seasonal activities in each of the regions. The material was written by specialists in the Department, or occasionally in the State experiment stations, and was assembled by the Radio Service into collections of sufficient size and diversity to make an interesting ten- or fifteen-minute program weekly in each region.

Arrangements are made with broadcasting stations in each of the regions to handle one or more of the syndicated programs weekly, or at longer intervals. The assembled material is mimeographed and mailed to each coöperating station sufficiently in advance of the broadcasting date to insure its certain arrival. These programs have increased in number and in frequency of broadcasting as the work has developed. They cover all phases of agriculture and home economics, together with some phases of agricultural economics and conservation. Among the general programs now

in operation, with the intervals at which they are furnished, and the number of coöperating stations for each, are the following:

Farm Flashes, sent daily to 109 stations
Farm Reporter at Washington, sent daily to 66 stations
Housekeepers' Chat, sent daily to 134 stations
Farm Science Snapshots, sent weekly to 88 stations
Primer for Town Farmers, sent weekly to 85 stations
Uncle Sam At Your Service, sent weekly to 98 stations
Chats with the Weather Man, sent bi-weekly to 110 stations
With Uncle Sam's Naturalists, sent bi-weekly to 83 stations
Agricultural Situation Review, sent monthly to 107 stations

The Federal Farm Board and the Children's Bureau of the Department of Labor have contributed a weekly syndicated program each, the first in the domain of agricultural economics, and the second in the interest of child welfare, including the rural child. These programs, though prepared wholly in the Federal units named, have been invited by and contributed through the radio service of the Federal Department of Agriculture.

In these syndicated programs, under which the material is furnished from the Department and the broadcasting is done by employees of the radio stations, particular attention is given to improved farming and homemaking practices. The rural public, especially, is given, besides, the reasons for certain important national or regional campaigns carried on jointly by the Federal and the State governments. Among such enterprises are tuberculosis eradication, tick eradication, barberry eradication, and white pine blister-rust control, etc.

Network Programs

The Federal agencies involved in network broadcasting are primarily the Radio Service in the Office of Information, U. S. Department of Agriculture, and secondarily the Federal Farm Board, the U. S. Army Band, and the Marine Band. Within the States, the coöperative Federal-State Agricultural Extension Service at the Colleges of Agriculture, and the Bureaus of Markets or other marketing units of the State Departments of Agriculture, take an active part.

Network broadcasting, consisting of national or regional hook-ups of from three to thirty-eight stations, for the regular programs,

and some thirty-three or thirty-four stations for special programs, is a relatively recent advance in radio service. In these programs the broadcasting is done by the staff of the Federal Department of Agriculture, mostly in Washington, but often at the larger cities scattered over the country. This work was begun by the Federal Department on a small scale in 1929 in the States of the Midwest and Southwest. On July 8, 1930, the Farm and Home Hour was made national in extent over a network of thirty-eight stations. However, because of the time differential of three hours, and also because of differences in agricultural conditions between the eastern United States and the parts west of the Rocky Mountains, it was not found feasible to continue a general nation-wide network program. Accordingly, a western network program unit was established in San Francisco, California, in December, 1930, and a western program of the Farm and Home Hour was opened on January 1, 1931. This unit employs a network of eight stations situated west of the Rocky and Wahsatch Mountains. Of these eight stations, three are in California—at Oakland, Los Angeles, and San Diego.

The Western Farm and Home Hour program is given daily from Monday to Friday, for a period of forty-five minutes. Usually the program is varied. The National Broadcasting Company provides about twenty-five minutes of entertainment features. The United States Daily furnishes four minutes of Government news, and the U. S. Department of Agriculture or the Federal Farm Board contributes sixteen minutes of agricultural information. Occasionally, however, the entire forty-five minutes may be devoted to a single topic of agricultural information, such as a summary of the outlook report of agriculture for the current year.

The agricultural and homemaking information composing this western Farm and Home Hour covers:

Market trends and outlook for major western commodities;

Facts about the service and regulatory activities of the Department which consumers and producers can use in their businesses;

Western conservation work of Federal and State governments and the coöperation expected from the public in these enterprises;

Current recommendations by the State agricultural extension service for improved farming and homemaking practices;

Current work of the Federal Farm Board for western farmers' cooperative marketing association;

Other information from the Department or its cooperating agencies, useful to western farmers and homemakers.

All agricultural information which needs to be put out as promptly as possible after it is obtained is broadcast through the network program rather than through the slower syndicated programs. The economic reports on agriculture must be in the hands of millions of farmers promptly to be of maximum value. These include the monthly crop reports, the report on the agricultural situation, the report on the price situation, the monthly reviews of the market situation, announcements of new quarantines or revision of existing regulations, and emergency reports on the extent, destructiveness, and control of diseases of farm animals, such as hog cholera, etc.

Another activity, begun in 1931, is a western network program entitled *Safeguarding Your Food and Drug Supply*, broadcast over a chain of three Pacific Coast stations by the chief of the western district of the Food and Drug Administration, whose headquarters are in San Francisco. This program, as planned, was to be carried weekly for at least 39 weeks.

Special network presentations outside the regular scheduled programs are arranged by the Radio Service and carried by coast-to-coast networks of thirty-three or thirty-four stations. Recently, these have included a Silver Anniversary program for the U. S. Forest Service and the program for the third annual National 4-H Camp Radio Night. This latter is a feature of the annual national encampment of delegates from the 4-H clubs of the State agricultural extension services.

The broadcasting in the national and regional networks from Washington is done by representatives of the subject-matter bureaus of the Department of Agriculture, and the Federal Farm Board. The Western Farm and Home Hour is broadcast by Mr. R. H. Lamb, director of the western radio program, who is quartered in the Appraiser's Building, Washington and Sansome Streets, San Francisco. The special Western Food and Drugs program is broadcast by the western director of that administration as noted above.

The California Agricultural Extension Service, and the Califor-

nia Department of Agriculture through its Bureau of Markets, cooperate either in preparing material for this program, or in broadcasting, or both. The National Broadcasting Company, by whose invitation the western program was inaugurated, contributes the radio facilities and the time for the transmission of these programs. There is no formal written agreement with the company but a general verbal understanding with its officials and with the managers of cooperating radio stations that these stations will carry the different programs at the appointed hour. Eventually, cooperation with agricultural organizations will be effected.

Office space is furnished to the western headquarters in the Appraiser's Building at San Francisco under the jurisdiction of the Treasury Department. Temporarily, however, the space used is a portion of that assigned to the Food and Drug Administration of the U. S. Department of Agriculture, which, likewise, for the time being, provides office furniture and supplies.

The attitude of the Radio Service toward State cooperation is shown by the following (81—1930 :16) :

The present task of the Department of Agriculture in its extension broadcasting is to bring the local radio stations with which it has contact into closer relation, not with Washington, but with the State agricultural college and its extension field force. When the agricultural colleges are equipped with the editorial personnel to work with the department radio writers, the department radio service should turn over contacts with individual stations to the colleges and become a service agency to them, rather than direct to the stations. Its task will then be to provide department information not available at the State agricultural college, prepare it for effective radio presentation, and supply it to the college to be incorporated in the college radio program through stations in its State.

The entire financing of this western project, with the exception of the broadcasting facilities furnished by the National Broadcasting Company, is borne by the U. S. Department of Agriculture. Personnel consists of the western radio program director and a clerk-typist. For the fiscal year 1932, the estimated budget is \$7240.

The publications listed in the Literature Cited at the end of this chapter which have been cited in this section on Information Service are Nos. 6a, 8, 31, 32, 40, 42, 46, 47, 48, 49, 52, 55, 57, 58, 61, 66, 76, 77, 79, 81, 82, 83, 84, 86, 90, 91, 92, 93, 94, and 95.

6. SUMMARY OF COÖPERATION

AGRICULTURAL EDUCATION includes resident teaching, experimentation and research, extension by demonstration, and various information services. Federal coöperation with the States in agricultural education has existed for nearly seventy years. It was begun in 1862 through the Act establishing the land-grant colleges. It has steadily increased in volume and scope since that time, especially in the last twenty years.

RESIDENT TEACHING

The land-grant colleges in general are independent State institutions. They were established under Federal legislation of 1862, granting lands for State colleges of agriculture. Small Federal money subsidies were added in 1890 and 1907. Detailed annual statistical reports have been required from each such college to the Secretary of the Interior since 1862, and to the Secretary of Agriculture since 1890. The Departments of Agriculture and Interior have published summaries of these annual reports, and many other data as well, for the benefit of all the institutions concerned. The Department of Agriculture coöperates fully with committees of the Association of Land-Grant Colleges and Universities. Recently the two Departments and the Land-Grant Colleges have coöperated in an extensive survey of the development, present status, and future objectives of these latter institutions.

In 1917 Congress created the Federal Board for Vocational Education, and provided for complete coöperation between the Federal Government and the several States in the vocational training of students in agriculture and home economics. The training of teachers for these subjects also was included. In 1920, coöperation was extended to cover vocational rehabilitation training for disabled citizens. Both vocational education and rehabilitation are based on the matching of Federal funds by the accepting States. In addition, large funds are provided by coöperating local educational agencies. State programs are subject to Federal approval.

EXPERIMENTATION AND RESEARCH

Federal-State coöperation in research has developed rapidly since the Federal creation and money subsidy of State Agricultural Ex-

periment Stations in 1887. The amount was doubled by an Act of 1906, and that total trebled by an Act of 1925 and thereafter. The general Federal supervision has been amplified to cover Federal approval of State projects under the last-named acts, and an annual Federal audit of expenditures thereunder. There also is large and steadily increasing coöperation between the U. S. Department of Agricultural and coördinating committees of the Association of Land-Grant Colleges and Universities. The most extensive coöperation is between the Department and the individual stations, or groups of stations, on specific research projects, mutually planned, financed, and supervised. For the benefit of all the stations the Department compiles and publishes, usually annually, certain detailed information on the work and expenditure, projects, personnel, and publications of the stations, coöperates in publishing the results of research, and conducts an abstracting journal for summarizing the results of departmental, station, and foreign investigations.

EXTENSION BY DEMONSTRATION

Coöperative extension services, beginning in a small way in 1904, were made a nation-wide coöperative Federal-State enterprise in 1914 through the passage of the Smith-Lever Agricultural Extension Act. This provides large annual Federal funds, required to be matched by State funds, which in turn are supplemented by still larger contributions from counties and other agencies. Coöperative demonstrations on farms are conducted by county agricultural advisors and their assistants. Similar demonstrations in farm homes are carried on by home-demonstration agents, while active extension instruction is given farm boys and girls through nation-wide series of 4-H clubs. The whole system, supervised and coördinated by the Federal agency, is operated coöperatively through the State and county agencies.

INFORMATIONAL SERVICES

The information services comprise a very extensive and varied series in which the Federal Department of Agriculture, the State Agricultural Colleges and Departments of Agriculture, and some other Federal and State agencies work effectively together.

Library services include Federal deposit of Federal publications

in designated libraries, international exchange of publications, and interlibrary book loans, Federal and State. They cover also the Federal preparation of indexes and bibliographies in various subject-matter fields. The visual education services include Federal, State, and local coöperation in the preparation and display of exhibits and in the making and use of lantern slides and motion pictures. The news services cover the coöperative preparation, distribution, and use of up-to-the-minute information on agricultural discovery and progress, market news, crop and livestock quantity and condition, and weather forecasts. The radio news services present the same types of information for radio broadcasting.

7. LITERATURE CITED

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11. Eisenhower, M. S., and A. P. Chew (with the assistance of officials in all the Bureaus and Offices of the Department). The United States Department of Agriculture: its growth, structure, and functions. U. S. Dept. Agr. Misc. Publ. 88:i-iv, 1-147, 21 charts (unnumbered), September 1, 1930.

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16. Federal Board for Vocational Education. Opportunity Monographs. Vocational Rehabilitation Series 1-44, November, 1918 to March, 1920.

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The report of the Committee after making the investigation, with suggestions for necessary changes, is included as House Report No. 1104, Rehabilitation of Disabled Soldiers, on pp. 2161-65.

42. U. S. Department of Agriculture. Report of the [Commissioner] Secretary of Agriculture for the year ———, 1862-.

Report of the Commissioner, 1862-88; Report of the Secretary, 1889-. From 1862 to 1920, inclusive, and for 1922 and 1923, the reports of Chiefs of Offices, Divisions, and Bureaus are included with the report of the Secretary in a consecutively paged volume. For 1921, and for 1924 onward, all these reports are issued separately each year, with separate paging. (See also Yearbooks.)

43. U. S. Department of Agriculture. Department Bulletins 1-1500, 1913-29. All Bureau series of publications were discontinued on June 30, 1913, and various Departmental series were begun on July 1. The Department bulletins are designated simply *Bulletins* until after No. 1100, when the word *Department* was inserted. This series of *Department Bulletins* was succeeded by *Technical Bulletins* and *Miscellaneous Publications*, the issuance of which, however, began in 1927.

44. U. S. Department of Agriculture. Technical Bulletins 1-, 1927-.

45. U. S. Department of Agriculture. Circulars 1-, 1927-.

Circulars in this series should not be confused with those in the series designated *Department Circulars* (Nos. 1-425, 1919-27), or with those in the series designated *Miscellaneous Circulars* (Nos. 1-, 1923-).

46. U. S. Department of Agriculture. Department Circulars 1-425, 1919-27. They should not be confused with the series known as *Miscellaneous Circulars*, established in 1923, or with the series designated simply *Circulars* (Nos. 1-, 1927-).

47. U. S. Department of Agriculture. Miscellaneous Circulars 1-, 1923-. This series should not be confused with the series designated *Department Circulars* (Nos. 1-425, 1919-27), or with the series designated simply *Circulars* (Nos. 1-, 1927-).

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49. U. S. Department of Agriculture. Official Record 1-11, 1922-32. 4to, weekly.

50. U. S. Department of Agriculture. Reports 1-117, 1862-1917.

Nos. 1-58 were issued 1862-98, without numbers. A list of titles and assigned numbers for this series was printed on cover pages 3 and 4 of No. 59, which was the first to bear a number.

51. U. S. Department of Agriculture. Miscellaneous Special Reports 1-10, 1833-86.

52. U. S. Department of Agriculture. Yearbook of the Department of Agriculture, — [year]. 1894-.

From 1894 to 1928 the statistical and other data were for the year named in the title and the volume was published in the following year. Beginning with 1930, the year in the title is the year of issue and the contained data are for the previous year, a most confusing condition. Through this change there is no volume bearing 1929 in its title.

53. U. S. Department of Agriculture, Office of the Secretary. Association of American Agricultural Colleges and Experiment Stations. Convention held at the Department of Agriculture, Washington, D. C., October, 1887. Report of the Committee on Station Work. Published by the Commissioner of Agriculture, 1888, 32 pages. Issued as an unnumbered publication but later designated as Report 45.

This report represents in some measure the proceedings of the first annual convention. For succeeding *Proceedings*, see Office of Experiment Stations, *Miscellaneous Bulletins* 1-3, and *Bulletins* between 7 and 228, inclusive (Entry Nos. 64 and 65). Thereafter published privately by the Association (Entry No. 2).

54. U. S. Department of Agriculture, Office of the Secretary. Circulars 1-183, 1896-1921.

Not to be confused with other series of *Circulars*, issued by the Department itself, rather than by the Office of the Secretary.

55. U. S. Department of Agriculture, Bureau of Agricultural Economics. Annual Report of the Chief of the Bureau of Agricultural Economics. 1923-.

For earlier annual reports see Office of Markets and Rural Organization for fiscal years 1915-17; Bureau of Markets for 1918-21; and Bureau of Markets and Crop Estimates for 1922. See also note under Entry No. 42.

56. U. S. Department of Agriculture, Bureau of Agricultural Economics. Branch Office Directory. Unnumbered, mimeographed publications of about 30 pages each (8½" × 11"), issued at irregular intervals.

57. U. S. Department of Agriculture, Bureau of Agricultural Economics. *Agricultural Economics Bibliography* No. ———. Nos. 1–, 1925–.

Forty numbers, issued at irregular intervals, mimeographed, 8½" × 11". Earlier numbers have been revised, revised editions of No. 1 appearing in 1927, 1929, 1930, and 1934; and of No. 2 in 1927. Some are of enormous size. No. 31: California; An index to the State sources of agricultural statistics, comprises 5 parts, of which Part I contains 724 pages, Part II has 430 pages, and the four parts so far issued contain some 1400 pages.

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Volumes consist of 12 monthly issues, mimeographed, 8½" × 11".

59. U. S. Department of Agriculture, Bureau of Animal Industry. Report of the Chief of the Bureau of Animal Industry for ——— [year]. 1884–.

This series of administrative reports should not be confused with the series of technical volumes issued from 1884 to 1905 as *Annual Reports of the Bureau of Animal Industry*, First to Twenty-second, inclusive. See also note under Entry No. 42.

60. U. S. Department of Agriculture, Bureau of Animal Industry. Directory of the Bureau of Animal Industry.

An unnumbered 8vo publication, first issued on January 20, 1910, and revised at frequent intervals thereafter, thus making 40 consecutive revised issues by 1933.

61. U. S. Department of Agriculture, Office of Exhibits. Report of the Office of Exhibits, 19——, 1922–23.

Reports for 1913–21 are in the annual report of the Secretary of Agriculture. Those for 1924 onward appear in the annual reports of the Extension Service. See Entries Nos. 76 and 79.

62. U. S. Department of Agriculture, Office of Experiment Stations. Report of the Director [now Chief] of the Office of Experiment Stations for ——— [year]. 1888–.

For the fiscal years 1916 to 1923, inclusive, the Office of Experiment Stations was a component part of the States Relations Service and its annual administrative reports will be found in the report of the Director of that Service. (See note under Entry No. 42.)

63. U. S. Department of Agriculture, Office of Experiment Stations. *Annual Report of the Office of Experiment Stations*. 1901–12, 1902–13.

These technical annual reports should not be confused with the administrative report of the Chief of the Office of Experiment Stations, issued annually from 1888 to date. (See Entry No. 62.)

64. U. S. Department of Agriculture, Office of Experiment Stations. *Bulletins* 1–256, 1889–1913.

65. U. S. Department of Agriculture, Office of Experiment Stations. *Miscellaneous Bulletins* 1–3 (all), 1889–91.

These three *Miscellaneous Bulletins* contained the proceedings of the second, third, and fourth annual conventions of the Association of American Agricultural Colleges and Experiment Stations. Thereafter, those proceedings were published in the bulletin series of the office. (Entry No. 64; see also Entry Nos. 2 and 53.)

66. U. S. Department of Agriculture, Office of Experiment Stations. *Circulars* 1–118, 1889–1913.

67. U. S. Department of Agriculture, Office of Experiment Stations. Federal legislation, regulations, and rulings affecting land-grant colleges and experiment stations. U. S. Dept. Agric., Dept. Circ. 251:1–56. Issued April 4, 1923; rev. April, 1925; rev. Sept., 1930 (60 p.).

68. U. S. Department of Agriculture, Office of Experiment Stations. Report on work and expenditures of the agricultural experiment stations, 19——. 1915—.

Unnumbered publications, usually varying between 60 and 160 pages each. The title has varied at intervals. From 1925 onward it reads: Report on the agricultural experiment stations, 19——. From 1915 to 1917, inclusive, the report on experiment stations and the similar one on extension work were issued as Part I and Part II of a single publication but with the two parts separately paged. From 1901 to 1912 these data were published in the Annual Report of the Office of Experiment Stations (Entry No. 63).

69. U. S. Department of Agriculture, Office of Experiment Stations. A classified list of projects carried on by the agricultural experiment stations, 19——. 1919 to 1921 (calendar years), 1923 and 1925 to 1927 (fiscal years).

Unnumbered mimeographed publications, 8½" × 11", of 200 to 400 pages each. The list for 1930 was printed as *Miscellaneous Publication* No. 89, and none has been issued since.

70. U. S. Department of Agriculture, Office of Experiment Stations. List of workers in subjects pertaining to agriculture and home economics in the United States Department of Agriculture and in State Agricultural Colleges and Experiment Stations, corrected to —— —, 19——. Unnumbered publ., 1914—17.

Four issues, corrected to June 1, 1914; August 1, 1915; December, 1915; and January, 1917, respectively. In the last, the list of workers in the Department of Agriculture was paged separately from that of the colleges and stations. For earlier issues, see Office of Experiment Stations, Bulletins (Entry No. 64).

71. U. S. Department of Agriculture, Office of Experiment Stations. List of workers in subjects pertaining to agricultural and home economics. Part II. State Agricultural Colleges and Experiment Stations, 19—— to 19——. 1917—18 to 1921—22 (except 1919—20). 1918—22. Unnumbered publs., nearly 100 p.

Part I was the list of workers in the U. S. Department of Agriculture. For later issues see *Miscellaneous Circulars and Miscellaneous Publications* of the Department (Entries No. 47 and No. 48).

72. U. S. Department of Agriculture, Office of Experiment Stations. List of publications of the Agricultural Experiment Stations in the United States (to June 30, 1906). U. S. Dept. Agric., Off. Exp. Stat., Bul. 180:1—104, 1907.

Many of the stations antedate the passage of the Hatch Act in 1887. The Pennsylvania station, for example, dates from 1869, and its early publications are cited.

73. U. S. Department of Agriculture, Office of Experiment Stations. List of Bulletins of the Agricultural Experiment Stations in the United States from their establishment to the end of 1920. U. S. Dept. Agric., Dept. Bul. 1199: 1—186, May 26, 1924.

"This bulletin lists approximately 12,500 of the 17,500 or more publications of the State experiment stations (including those of Alaska and the insular possessions) from 1875 to 1920, inclusive. It is confined primarily to the regular bulletin series of the stations. It does not include circulars and other more or less ephemeral publications; annual reports, except such as are numbered as bulletins; nor scientific contributions from the stations which have appeared in the *Journal of Agricultural Research* or other scientific periodicals." [p. 1]

74. U. S. Department of Agriculture, Office of Experiment Stations. List of bulletins of the agricultural experiment stations for the calendar years 19— and 19—.

- 1921 and 1922 Dept. Bul. 1199, Supplement 1:1-24, 1924.
- 1923 and 1924 Dept. Bul. 1199, Supplement 2:1-54, 1926.
- 1925 and 1926 Dept. Bul. 1199, Supplement 3:1-62, 1927.
- 1927 and 1928 Misc. Publ. 65:1-78, 1930.
- 1929 and 1930 Misc. Publ. 128:1-88, 1932.
- 1931 and 1932 Misc. Publ. 181:1-77, 1934.
- 1933 and 1934 Misc. Publ. 232:1-81, 1936.
- 1935 and 1936 Misc. Publ. 294:1-94, 1938.

75. U. S. Department of Agriculture, Office of Experiment Stations. General Index to Experiment Station Record:

- Vols. 1-12, 1889-1901, 671 p., 1903.
- Vols. 13-25, 1901-1912, 1159 p., 1913.
- Vols. 26-40, 1912-1919, 640 p., 1926.
- Vols. 41-50, 1919-1924, 709 p., 1931.
- Vols. 51-60, 1924-1929, 667 p., 1933.

76. U. S. Department of Agriculture, Extension Service. Report of the Director of the Extension Service. 1924-30.

For earlier reports, see Report of the Director of the States Relations Service (Entry No. 86). For later reports, see Report of Extension Work in Agriculture and Home Economics in the United States (Entry No. 79).

77. U. S. Department of Agriculture, Extension Service. Extension Service Circulars 1-, 1926-, mimeographed, 8½" x 11".

78. U. S. Department of Agriculture, Extension Service. Coöperative Extension Work, 192—. 1923-29, unnumbered annual publication, 1925-31.

79. U. S. Department of Agriculture, Extension Service. Report of Extension Work in Agriculture and Home Economics in the United States, 19—. U. S. Dept. Agric., unnumbered publ., ——. 1931:1-136, May, 1932; 1932:1-80, June, 1933.

This report supersedes the annual report entitled *Report of the Director of the Extension Service*, last issued for the fiscal year 1930, and *Coöperative Extension Work*, last issued for the calendar year 1929. See Entries No. 76 and No. 78.

80. U. S. Department of Agriculture, Forest Service. Directory, Forest Service, April (or October), 19—. Unnumbered 8vo publications, 30 to 35 pages each, issued semiannually.

81. U. S. Department of Agriculture, Office of Information. Report of the Director of Information, 1928-. 1926 and 1927 apparently not issued, 1928 mimeographed.

82. U. S. Department of Agriculture, Library. Report of the Librarian for ——. 1894-. None printed in 1895, 1896, and 1897. (See note under Entry No. 42.)

83. U. S. Department of Agriculture, Library. Bulletins 1-76, 1894-1912.

84. U. S. Department of Agriculture, Library. Bibliographical Contributions 1-22, 1919-31.

85. U. S. Department of Agriculture, Bureau of Plant Industry. Report of the Chief of the Bureau of Plant Industry for ——— [year]. 1901-, 1901-. (See note under Entry No. 42.)

86. U. S. Department of Agriculture, States Relations Service. Report of the Director of the States Relations Service. 1916-23, 1917-24. (See note under Entry No. 42.)

87. U. S. Department of the Interior, Office (formerly Bureau) of Education. Annual Report of the Commissioner of Education. 1868-.

From 1868 to 1888, inclusive, a single comprehensive volume was issued each year. From 1889 to 1917, inclusive, two comprehensive volumes (1 and 2) were issued annually. From 1918 onward, the comprehensive data are issued in the Bulletins and the annual administrative report is a paper-bound pamphlet.

88. U. S. Department of the Interior, Office (formerly Bureau) of Education. Bulletins, 1906-.

The issues of each calendar year are numbered from No. 1 onward, thus making it necessary to cite the year as well as the issue number in order to identify any given issue, as "1930, No. 8."

89. U. S. Department of the Interior, Office of Education. Digest of legislation providing Federal subsidies for education, by Ward W. Keesecker. U. S. Dept. Int., Off. Educ., Bul. 1930 (8):1-52, 1930. (See Entry No. 24.)

Part I, Grants for common schools; Part II, Universities, seminaries of learning and normal schools; Part III, Colleges of agriculture . . . , and agricultural experiment stations; Part IV, Land granted for industrial and reform schools, charitable purposes, military institutes, scientific schools, schools of mines; Part V, Vocational education; Part VI, Literature . . . Federal subsidies for education.

90. U. S. Government Printing Office. Annual report of the Public Printer, ——— [year]. 1853-. Title varies, especially in early reports.

91. U. S. Government Printing Office. Classified list of United States Government periodical publications available for selection by depositary libraries. 10 p. (Washington: Government Printing Office, 1930).

92. U. S. Government Printing Office, Superintendent of Documents. Annual Report of the Superintendent of Documents. 1st-, 1895-. 3rd report (1896-97) never issued. Title varies.

93. U. S. Library of Congress. The Library of Congress and its work. Report prepared for the Commission of the United States of America to the Brazil Centennial Exposition. For distribution at the Brazil Centennial Exposition, 1922-23. 16 p., unnumbered publ., 1922.

94. Walling, William English, and Harry W. Laidler. State Socialism: pro and con. Official documents and other authoritative selections—showing the world-wide replacement of private by governmental industry before and during the war. With a chapter on municipal socialism, by Evans Clark. 649 p.; Extension Service, pp. 143-49; Experiment Stations, pp. 149-53.) (New York: Henry Holt & Co., 1917.)

95. Wiest, Edward. Agricultural organization in the United States. Univ. Kentucky: Studies in Economics and Sociology, 2:i-xxiii, 1-618, 1923. (The States Relations Service, including the Office of Experiment Stations and the Extension Service, pp. 57-65.)

Chapter VIII: AGRICULTURAL ENGINEERING

[Because each chapter covers a different subject and therefore will be used chiefly by a different constituency, it seems desirable to make each one complete and self-contained. For this reason, among others, a complete table of chapter contents is placed at the beginning of each chapter, rather than at the front of the volume. A list of all literature cited in the chapter will be found at the end of the chapter and the numbers in parentheses in the text refer the reader to the corresponding entries in this list. All entry numbers occurring in each major section of a chapter also are listed in numerical sequence at the end of that section, thus forming what is in effect a section list of literature cited. These features all should prove of great convenience to readers.]

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Chapter VIII

AGRICULTURAL ENGINEERING

1. INTRODUCTION

AGRICULTURAL ENGINEERING is an important and still increasing phase of agricultural teaching, research, extension, and practice. Although activities in farm engineering are comparatively recent, the volume of coöperation has grown rapidly and now is relatively extensive. As the economic phases of agriculture now are dominant, there should be further rapid development of activities in this field of engineering and in the coöperative relations of the official agencies concerned.

DEFINITION AND SCOPE

The Committee on Methods of Teaching Agriculture, of the Association of American Agricultural Colleges and Experiment Stations, defined rural engineering in 1901 as "the science and art of laying out farms, designing and constructing farm buildings and works, and making and using farm implements and machinery" (42—45).*

Agricultural engineering may be said to include all the wide and diverse range of engineering activities affecting the farm. Within this range it involves design, construction, maintenance, protection, repair, and use. Collaterally, it often involves the physics and chemistry of the soil, and it deals also with climatic forces and their effects.

Agricultural engineering already has developed some six different departments. Arranged somewhat in the order of their development as objects of study, these are irrigation engineering, drainage engineering, erosion engineering, farm-land-efficiency engineering, farm machinery and equipment, and farm structures.

The first four have a more or less definite relation to land as a natural resource, and some mention of this aspect of the subject will be made in the chapter on Land in the volume on Natural Re-

* Numbers in parentheses refer to the Literature Cited, at the end of the chapter.

sources. These four might properly be grouped under the single comprehensive term, land-reclamation engineering, or land-use engineering. As they constitute the major portion of the chapter, however, and often are administered by different official agencies, it seems desirable to treat them as separate and coördinate in this presentation.

Irrigation engineering belongs primarily to the chapter on Water Resources in the volume on Natural Resources. It will be discussed in the present chapter only as it relates directly to agricultural production, omitting all those aspects which are concerned primarily with water conservation.

Erosion engineering, for a long time largely restricted to a relatively minor study of terracing, recently has assumed the proportions of a major branch of agricultural engineering. Farmland-efficiency engineering is so new that it may be regarded as just in its infancy. With the growing realization of the grave economic importance of land utilization, it seems likely to develop to a remarkable extent in the next decade.

HISTORICAL DEVELOPMENT

During the last half of the nineteenth century, irrigation engineering received an enormous impetus in this country through the rapid settlement of the arid or semiarid States of the West. The transfer in 1850 of the swamp lands of the public domain to most of the States by the Federal Government gave rise to drainage problems on a large scale. In the early years of this period, legal problems having to do with conflicting water rights and the organization of private drainage enterprises were most important. These were handled by irrigation and drainage commissions, or by the office of State engineer in the various States. In the meantime, the State agricultural colleges were developing, and their departments of civil engineering and mechanical engineering began to give attention to drainage and irrigation problems. In the latter part of the period, the development of the agricultural experiment stations added impetus to studies in these fields. It was only when the economic problems of agriculture became dominant, however, that governmental attention was directed to agricultural engineering on any large scale.

Toward the end of the last century, the increase in irrigated acreage without corresponding increase in available water supplies made the question of water rights more acute, and led to extensive research on the duty of water and the prevention of waste. At the same time, seepage and overflow in irrigated lands gradually brought about a drainage problem of huge proportions. The depression of the middle nineties made economies in farm labor necessary, and created a demand for large-scale machinery. Attention began to be paid to construction of farm structures from the standpoints of sanitation, economy, efficiency, and convenience. Last of all, the problems of mechanical control of erosion and the clearing of land by machinery began to take shape just about the turn of the century.

Early State Activities

In the States, all the six branches of agricultural engineering mentioned above received some consideration by official agencies before the end of the last century. The experiment stations of the State colleges of agriculture began to give attention to agricultural-engineering problems immediately after their establishment. Some of the colleges already had done so. Before the end of 1900 many of them, including some eastern State stations, had published on irrigation, and a few had issued bulletins on drainage. Farm machinery and equipment, including tillage and harvesting implements, spraying machinery, cream separators, and windmills had come in for widespread station attention from 1888 to 1900. In the same period the construction of silos was published upon abundantly, and after 1895 some attention was given to construction and ventilation of barns. Greenhouses, hotbeds, storage cellars, water supply, and lightning rods scored one bulletin each. Land clearing and erosion control each were represented also by a single bulletin during the period.

Committees of the Agricultural College Association

The Association of American Agricultural Colleges and Experiment Stations took official notice of agricultural engineering problems just at the end of the last century. In about 1896 the Association created its Committee on Methods of Teaching Agriculture. In its fifth report, this committee presented the syllabus of a course

in rural engineering (42—45:6-7), which was published in 1901 by the Office of Experiment Stations.

At its annual meeting in November, 1902, the Association appointed a Committee on Rural Engineering. This was the result of a resolution reciting that the colleges and stations as well as the Federal Department of Agriculture were broadening their work relating to irrigation, farm machinery, and other branches of agricultural engineering, and that there was pressing need of more definite formulation of plans for this work. It was made the duty of the committee to coöperate with the Department of Agriculture in promoting education and research along the different lines of agricultural engineering. This committee reported to the Association (41—142) at its meeting in November, 1903, and its report was promptly published by the Office of Experiment Stations (42—53).

The committee repeated the definition of rural engineering, given above, as "the science and art of laying out farms, designing and constructing farm buildings and works, and making and using farm implements and machinery" (42—45).

The committee recorded its belief that there should be a strengthening of the courses of instruction in agricultural engineering subjects in the land-grant colleges, and that comprehensive investigation should be started to provide up-to-date information for such instruction. The committee then proceeded to discuss the various activities in civil and mechanical engineering which might be comprised under the general term *rural engineering*. These were the laying out and arrangement of the different fields in a given farm, the construction and grouping of farm buildings, including the use of different construction materials, and the introduction of labor-saving devices; the whole range of irrigation problems including water rights, water distribution, and the duty of water; the problems of drainage and effective drainage structures, the prevention of erosion through terracing and draining sloping lands, the construction of rural roads, and a systematic study of the manufacture and use of agricultural machinery.

The committee also recorded its belief that coöperation between the Department of Agriculture and the agricultural colleges and experiment stations in the problems of irrigation and drainage

should be more fully developed, the Department coördinating the work of the stations, and aiding them in carrying out the original researches. Finally, the committee recommended that the Association of Agricultural Colleges and Experiment Stations declare itself in favor of the creation of separate departments of rural engineering in the colleges, that it heartily support the Department of Agriculture in extending its work along these lines, and that it urge upon the Congress the importance of giving the Department more liberal appropriations for these purposes. These recommendations all were endorsed by the Association at its annual meeting.

Early Federal Activities

In the meantime, Federal activity had begun. In 1890, the Congress established an Office of Irrigation Inquiry in the Department of Agriculture (45—1890—95). This Office was continued to the end of the fiscal year 1895. In 1898, after a lapse of two years, the Office of Experiment Stations began an investigation of irrigation problems, and in the next year established a Division of Irrigation Investigations. In 1901, the Secretary of Agriculture discussed the possibility of a change in Federal policy which would permit national aid for irrigation enterprises (26—1901:89—92).

As early as 1900 the Office of Experiment Stations recognized that a drainage problem was developing on swamped lowlands in irrigated areas, and suggested a Government investigation. From 1900 to 1903, both the Secretary of Agriculture and the Office continued to dwell upon this problem and the Federal responsibility for helping farmers thus injured through no fault of their own. In 1902, requests for Federal help were received from Kings River farmers in California, and the State Engineer in Colorado, and studies were begun.

Agricultural engineering, other than that concerned with irrigation and drainage, is first mentioned officially by the U. S. Department of Agriculture in the report of the Secretary for 1901 (pp. 88—89). He advocated that the Department begin to occupy this field of investigation, including studies of farm power (especially for irrigation pumping), drainage engineering, water supply and sewerage sanitation, reservoirs and other devices for preventing

erosion (including a proper use of tillage machinery), and, finally, rural beautification.

From 1902 to 1905, both the Secretary of Agriculture and the Director of the Office of Experiment Stations continued to expand on the necessity of studies in agricultural engineering, and asked for appropriations for that purpose. It was pointed out that the agricultural colleges were establishing courses of instruction in farm mechanics, Wisconsin having created such a department in 1903, and that Federal-State coöperation therein had been arranged. In 1905 a Federal expert in farm machinery and power was appointed.

Agricultural engineering, as discussed above, included farm structures as well as farm machinery and implements, although it related chiefly to the two latter. In 1904, the Secretary pointed out that many recently built and expensive barns had not been properly ventilated and therefore had promoted development of tuberculosis among high-priced dairy herds. In 1905, coöperative experiments were begun with the Iowa and Wisconsin Stations on the cost and value of reinforced concrete and cement for farm structures as well as for flumes, pipes, and drains (39—1905:491).

The earliest official notice of erosion problems was taken by the Office of Experiment Stations in 1903, when preliminary studies were made in Florida, and a noncoöperative experiment started in Georgia on the effect of underdrains in preventing hillside erosion (40—1903:313).

OFFICIAL AGENCIES AND LITERATURE

As in the case of other lines of agricultural activity, Federal agencies, State agencies, and joint agencies were concerned in the development of agricultural engineering.

Federal Agencies

Federal attention to the six branches of present-day agricultural engineering has developed in three successive periods, and two branches have been developed more or less together in each of these periods.

Irrigation and drainage.—Irrigation and drainage investigations were the first and second activities under agricultural engineering to be developed. From 1890 to 1895, the U. S. Department

of Agriculture maintained an Office of Irrigation Inquiry under varying names. It issued annual reports (45), except in 1892, and a single bulletin, together with several reports (49—6:147—48) which were published as Congressional documents. Apparently no official attention was given to irrigation problems in the fiscal years 1896 and 1897.

In 1898, the Office of Experiment Stations in the Department of Agriculture began preliminary irrigation studies, an appropriation for such investigations having been asked and made effective for fiscal year 1899. A Division of Irrigation Investigations was established in that Office in 1899, and in 1902 this Division included drainage studies also. During fiscal years 1904 to 1907 the Division was designated Irrigation and Drainage Investigations. From fiscal years 1908 to 1915, there were two separate Divisions, Irrigation Investigations and Drainage Investigations, established on October 15, 1907.

In 1902, the Library of the U. S. Department of Agriculture published in its *Bulletin No. 41* a list of references to publications relating to irrigation and land drainage.

The publications of the Office of Experiment Stations on irrigation and drainage are found in the annual reports of the Director of the Office (39—1898—1915), in the technical annual reports of the Office (40—1901—12), in the *Bulletin* (41) and *Circular* (42) series of the Office, to June 30, 1913, and in the *Farmers' Bulletin* (27) series of the Department. After July 1, 1913, the bulletin and circular series of all Bureaus and Offices were superseded by the series of *Department Bulletins* (28) and *Department Circulars* (30), in which some publications on irrigation and drainage were published by the Office of Experiment Stations during the succeeding two-year period.

On July 1, 1915, the Irrigation Division and Drainage Division of the Office of Experiment Stations were transferred to the Office of Public Roads. These two divisions thenceforth became quasi-sections of a Division of Rural Engineering in the Office of Public Roads and Rural Engineering which, in 1919, became officially designated as the Bureau of Public Roads. During fiscal years 1916 to 1931 inclusive, the records of activities in irrigation and drainage will be found in the annual reports of the Chief of the (Office

and) Bureau of Public Roads, except for the two years 1926 and 1927, when the annual report of the Division of Agricultural Engineering was issued separately from the annual report of the Chief of the Bureau. Publications on irrigation and drainage thereafter were issued in the three Departmental series named above (Department bulletins and circulars and farmers' bulletins), and in the later-established series known as *Circulars* (32), *Miscellaneous Circulars* (31), *Miscellaneous Publications* (34), and *Technical Bulletins* (29).

On July 15, 1931, the Division of Agricultural Engineering, as it then was called, became independent as the Bureau of Agricultural Engineering, and accounts of its activities may be found in the annual reports of the Chief of that Bureau from fiscal years 1932 onward.

Farm machinery, equipment, and structures.—Only occasional and sporadic attention was given to engineering problems in farm implements and structures by the U. S. Department of Agriculture before comparatively recent years. Brief discussions of such matters in engineering appear in the *Annual Reports of the Secretary of Agriculture* (26—1901-6) and in the *Annual Report of the Director of the Office of Experiment Stations* (39—1902-6). In the technical *Annual Report of the Office of Experiment Stations* brief mention is made of these problems in the years 1902 and 1904 (40), and specially prepared papers are included in 1905 and 1908. No mention is made by either agency in 1906 and 1907.

In 1906, a Division of Farm Management Investigations was organized in the Bureau of Plant Industry. From 1908 to 1913, inclusive, mention of economic studies of farm machinery, farm power, and farm structures is made in the *Annual Reports* of the Chief of that Bureau (46), and in the *Annual Reports* of the Secretary of Agriculture (26), and some publications were issued. On July 1, 1915, this work in the Office of Farm Management of the Bureau of Plant Industry was transferred to the Office of Public Roads and Rural Engineering as a component part of the then-created Division of Rural Engineering. Since that time, the publications on materials in these fields have been issued in the same departmental series that were noted above for irrigation and drainage publications.

One natural and significant result of the Department's indefinite policy regarding agricultural engineering other than that concerned with irrigation and drainage was the development of special engineering interests in many Bureaus. The unsuccessful attempts to establish such engineering investigations in the Office of Experiment Stations between 1901 and 1905, and the lack of trained engineers in the Office of Farm Management which limited the scope of its engineering activities to a study of farm practice during the years from 1908 to 1913, gave these other Bureaus little reason to think that a definite engineering unit, able to meet their needs, was to be created in the Department. This condition was not immediately changed by the concentration of all engineering activities in the Office of Public Roads and Rural Engineering on July 1, 1915. Irrigation and drainage investigations were the dominant divisions of the new unit, and the work in farm machinery and farm structures had to be organized.

Only after the World War did the new Division of Agricultural Engineering begin to exert large influence on the engineering activities of other Bureaus. The result was that independent studies continued to be made and publications issued by the other Bureaus for several years after 1915. This condition resulted in part from the physical isolation of the new Division from the other Bureaus, so that there was not that helpful intermingling of the different personnels in corridors, lunchrooms, and other places of assembling, which make so largely for the exchange of ideas and the development of collaboration. Furthermore, individualism rather than coöperation was still the dominating principle in the Department until the emergency of the World War created the necessity of working together for speed and efficiency. When the change in relations began, the other Bureaus at first merely asked the Division of Agricultural Engineering to prepare plans and specifications for structures and apparatus, and this assistance was acknowledged by footnotes in publications. Later, actual coöperation developed, and, still later, joint authorship appeared. Just to list the independent engineering activities of other units than the Division of Rural Engineering is a revelation of the effect of the policies pursued during the previous two decades. Such activities in seven different units are given below.



The Bureau of Animal Industry, through its Divisions of Animal Husbandry and Dairying, was intimately concerned with structures used in the production of farm animals. Many publications on such structures were prepared by them and put out in the years after agricultural engineering was officially concentrated in the Bureau of Public Roads. In the series of *Department Circulars* the Bureau had published on brood coops and appliances (30—13), poultry houses (30—19), and the making of hog crates (30—46), all in 1919. *Farmers' Bulletins* so prepared were on the pit silo (27—825) in 1917, and in the same year on self-feeders for hogs (27—906); in 1918 on a hog-breeding crate (27—966), and on cooling milk and cream on the farm (27—976); in 1920 on poultry houses (27—1113); in 1923 on dairy-barn construction (27—1342) and also on natural and artificial incubation of hens' eggs (27—1363) with full discussion of the necessary apparatus and its operation; and in 1924, similarly, on the brooding of chickens (27—1376), and also on poultry-house construction (27—1413).

The Bureau of Chemistry, in about 1914, organized a unit first known as the Office of Development Work and later as the Division of Chemical Engineering. From its inception, it has been concerned with apparatus and equipment for preventing fires in grain separators, grain elevators, cereal mills, cotton gins, etc. Its first work, concerned with the installation of dust-collecting fans in grain separators, published (28—379) in 1916, was done in co-operation with the Division of Agricultural Engineering of the Bureau of Public Roads. All later investigations were collaborative with other units, including the Pennsylvania Engineering Experiment Station (28—681) and the Bureau of Markets (30—98). Publications on equipment of cotton gins to prevent fires, issued from 1919 to 1929, were not coöperative with engineering agencies (30—28 and 271; 32—76).

The Bureau of Entomology was concerned with machinery and apparatus for spraying and dusting various crop plants to prevent insect attack. In this interest they developed a considerable engineering activity which at first was carried on independently. By 1918, however, the magnitude of their problem and their limited training in mechanics led to coöperation with the Division of Agricultural Engineering.

The Office of Farm Management was transferred from Plant Industry to the Office of the Secretary on July 1, 1915, and at the same time its projects for studying farm machinery and farm structures were transferred to the Division of Agricultural Engineering. Nevertheless, much of its later study of farm practices naturally centered on the use and efficiency of improved, large-scale farm machinery. Until the Office was absorbed by the Bureau of Agricultural Economics, however, it developed no coöperative relations whatever with the Division of Agricultural Engineering. In its studies of haymaking and baling practices, it published at least six *Farmers' Bulletins* (27—838, 956, 987, 1009, 1021, and 1049) independently between 1917 and 1919. Tractor and gas-engine studies produced several independent bulletins (27—963, 1004, 1013 [gas engines], 1035, 1045 [laying out fields], and 1093). Other independent investigations included clearing land (27—974), machinery to save man labor (27—989), machinery for cutting corn (27—992), machinery for cutting firewood (27—1023), and machinery for saving man labor in sugar-beet fields (27—1042). These papers all appeared between 1917 and 1920.

The various field and laboratory activities of the Bureau of Plant Industry had caused it to undertake certain studies of machinery, apparatus, and structures. In 1917 it published on harvesting and threshing sweet-clover seed (27—836), with inclusion of detailed drawings of machines, and in 1918 on drying fruits and vegetables (27—984), with discussion of both structures and apparatus. As late as 1923, the Bureau issued a bulletin on greenhouse construction and heating (27—1318), giving detailed designs, with no mention of engineering coöperation.

The Bureau of Markets, in 1920 and 1921, published independent investigations of the engineering features of vegetable and fruit transportation, including apparatus and structures for proper refrigeration and cold prevention (27—1091 and 1145), and apple-packing houses (27—1204). Similar work had been done previously in the Bureau of Plant Industry (48—114).

The Weather Bureau had long maintained an Instrument Division for the designing and construction of its specialized new apparatus. In addition, it published on methods of protection against lightning, in a discussion of apparatus and its installation

(27—842) in 1917. For many years, also, it has studied methods and apparatus for prevention of frost damage in orchards (27—1096).

Some of the above-mentioned Bureaus issued publications which are not truly coöperative, but which acknowledge the assistance of the Division of Agricultural Engineering in preparing plans and specifications. These are not mentioned here but are discussed in the succeeding subject-matter sections of this chapter. Other investigations, coöperative between two or more Bureaus, but not including the Division of Agricultural Engineering of the Bureau of Public Roads, also are discussed hereafter.

Erosion-prevention and farm-development engineering.—No official engineering agencies were created to handle these agricultural problems until very recent years. Studies of erosion control had been made by the Forest Service and other coöperating agencies, and by the Bureau of Soils, at intervals during the last twenty years. In 1928, the realization of the importance of erosion problems had become so acute that steps were taken to provide for a series of erosion experiment stations, and in 1930 an appropriation was made by Congress. These stations are under the joint control of the present Soil Erosion Division of the Bureau of Chemistry and Soils, and the Division of Drainage and Soil Erosion Control of the Bureau of Agricultural Engineering. Published information is found in the annual reports of each of these Bureaus (36; 37; 50), and in the series of departmental publications mentioned heretofore. The beginning of farm-development engineering is still more recent. Special attention to it was first given by the Division of Agricultural Engineering of the Bureau of Public Roads in fiscal year 1929, when coöperative studies of land clearing were begun in several States. Even yet, there is no separate division charged with responsibility for this work, but it is listed under "Special Assignments" (34—123).

General literature.—Besides the special engineering publications mentioned in the preceding paragraph, there are some which discuss the history and the activities of the Federal agencies concerned with agricultural engineering. The annual reports of the agencies themselves, already mentioned, fall into this class. Others are treated below.

The Department of Agriculture itself has published a discussion of the activities and the organization of its component units, including the Division of Agricultural Engineering (8:126-32) in the Bureau of Public Roads. A mimeographed publication presenting the achievements of the Department during the World War discusses labor-saving machinery and licensing of farm-machinery manufacturers (16:13-15). The *Service Monographs* issued by the Institute of Government Research of the Brookings Institution describe the various Government bureaus. That one covering the Office of Experiment Stations (5:87-94) discusses irrigation and drainage (pp. 87-93) and agricultural engineering (pp. 93-94). Another, covering the Bureau of Public Roads (10:23-25, 38-40, and 51-55), to which Agricultural Engineering was transferred in 1915, presents both the distribution of surplus war explosives (pp. 23-25) and the history (pp. 38-40) and activities (pp. 51-55) of agricultural engineering. A third, covering the Bureau of Plant Industry (21b:11), merely makes mention of farm machinery, which had engaged the attention of the Office of Farm Management of that Bureau from about 1908 until about 1915. Two other studies of the organization and functions of the Department of Agriculture also make brief discussion of agricultural engineering. The first, a study of administration as represented by the U. S. Department of Agriculture, mentions briefly the organization and work of rural engineering (54:46 and 53). A second, dealing with agricultural organization in the United States, published in 1923 by the University of Kentucky (57:55-57), discusses the Division of Agricultural Engineering of the Bureau of Public Roads.

Finally, there are Federal publications which themselves contain lists of Federal and State publications. All the bulletins, circulars, and other series of publications of all the various Divisions, Offices, and Bureaus of the U. S. Department of Agriculture and of the Department itself have been arranged by units of origin. The first of these (9; 49-6) covered the period from 1840 to June, 1901. The second listed those publications of the twenty-five years from 1901 to 1925 (11; 34-9). The third covered the 5 years from 1926 to 1930 (12; 34-153), and the fourth (34-252) the 5 years from 1931 to 1935.

In a similar way, the Federal Office of Experiment Stations has compiled and published from time to time lists of the bulletins, special bulletins, and research bulletins but not the circulars or annual reports of the various State agricultural experiment stations. The first compilation covered the years from the establishment of the stations to 1920 (28—1199; 43). Since 1920, these lists have covered successive two-year periods, and eight have been published (28—1199; 34—65, 128, 181, 232, and 294; 44).

State Agencies

Numerous agencies within the several States are concerned with the problems of agricultural engineering. In many of the States, the office of State Engineer was created when irrigation problems first became important. Departments of agricultural engineering in the colleges of agriculture, and divisions of agricultural engineering in the experiment stations, have developed steadily since the very early years of the present century. These have been concerned primarily with teaching and research. The State supervisory and regulatory functions in connection with drainage and irrigation laws, districts, etc., have remained with the State Engineer.

State drainage commissions were created many years ago in some of the States which undertook the reclamation of swamp lands granted to them by the Federal Government in 1850 or thereafter. Some States created irrigation commissions also, at a later date. These commissions, however, were more concerned with the administration of drainage and irrigation laws than with the definitely engineering aspects of these reclamation problems.

In many cases, the former Office of State Engineer has been supplemented by a State Department of Conservation, State Department of Public Works, or other similar official body of much wider scope. In these the work formerly done by the State Engineer usually is a component part, even though the office of State Engineer be retained.

Through the years there has been a steadily growing volume of cooperation between these several agencies in attacking the engineering problems within their own States. As in Federal-State cooperation, these relations sometimes develop from personal desire on the part of the officers and sometimes from the mandatory

requirement of State legislation which provides for a joint handling of certain problems.

One of the most significant engineering movements has been the establishment of engineering experiment stations in the State universities and land-grant colleges, during the last three decades. In 1903, the University of Illinois became the first institution to establish such a station, with Iowa State College a close second in 1904. Five such stations were established in the first ten years, and thirteen in the second ten-year period. In 1921, a representative from the Bureau of Education reviewed the history of engineering experiment stations before the Section of Engineering in the Association of Land-Grant Colleges (1b—35:282-89). In 1925, the Section held a symposium on engineering experiment stations (1b—39:244-333), and at this time there were said to be twenty-eight such stations (p. 245). The following year, an index to programs and papers of the Engineering Section of the Association of Land-Grant Colleges from 1913 to 1926 was published (1b—40:320-31).

There has been no direct Federal support for these stations, although the engineers had made attempts in 1889, 1907, and 1916 to obtain appropriations. They are supported by State appropriations and by grants from private corporations and national associations for whom they undertake to solve research problems.

The published papers in the symposium mentioned comprise one on land-grant college engineering experiment stations (1b—39:244-52) and one on coöperative research in land-grant colleges (1b—39:314-24; 21a). The remainder are written or informal discussions of what was being done by the various stations. Naturally, most of the research conducted in these engineering experiment stations has had to do with industries other than agriculture. However, numerous projects have covered problems in drainage engineering, structures (especially concrete construction), ventilation, electric power, and waste disposal, all related to agriculture. Some of these projects have involved coöperation between State and Federal agencies as well as between different agencies within the various States.

In all investigations under agricultural engineering, it has been impossible to seek out the numerous instances of actual intrastate

relations in the several States. But if such intrastate relations have developed in connection with Federal-State coöperation discussed herein, they are mentioned.

SERVICES TO OTHER FEDERAL AGENCIES

The present Bureau of Agricultural Engineering, in its major lines of work relating to farm buildings, other farm structures, farm machinery and equipment, and erosion control, touches the work of practically every other Bureau of the Federal Department of Agriculture, as well as that of many other Federal and State agencies. In this the Bureau holds an all but unique position, for its operations require a technical skill not ordinarily possessed by the specialists in these other governmental units. Stations of the Bureau of Animal Industry, of Dairy Industry, or of Entomology, for instance, may grow the food plants necessary for their animals and insects without the aid of the plant-industry experts. On the other hand, the specialists of the Bureaus of Animal Industry, Dairy Industry, Entomology, and Plant Industry are not so well equipped to design and construct buildings, drainage, sewage, water supply, and irrigation systems, new machinery, and complicated apparatus, as are those trained in engineering. For these reasons the quantity of services rendered by the Bureau of Agricultural Engineering to the other units of the Federal and State Governments is out of all proportion to the size of this Bureau. A summary of the scope and character of these services is given below. The items were taken from the successive annual reports of the Division and Bureau (36; 50). One of the special services rendered was in detailing three different engineers at intervals, during 1919 to 1920, to assist the Joint Commission on Reclassification of Federal Salaries.

On Machinery and Apparatus

One of the important services rendered by the agricultural engineers to other units of the Government is in the design and construction of apparatus and machinery for experimental use in laboratory and shop and on the farm.

In 1917, a portable compressed-air sprayer was designed for use by the Bureau of Plant Industry in its field investigations—not to

specify a dozen or more designs for other pieces of laboratory equipment and experimental apparatus. In 1918, specifications for the rental and purchase of tractors and other farm implements were prepared for the Bureaus of Entomology and Plant Industry. In 1919, drawings of several pieces of chemical apparatus were made for the Bureau of Chemistry. The continuing design and improvement of dust-spraying apparatus for preventing boll-weevil damage to cotton is recorded in the discussion of coöperation on cotton machinery. During the next ten years it was recorded that much of the time of the Section of Structures was required in designing and preparing specifications for equipment and buildings to be used by other Bureaus of the Department of Agriculture.

Among the items of service rendered during the last four years are specifications for electric motors, meters, heaters, and generating sets, made for various Bureaus of the Department; laboratory-equipment designs for the Bureau of Dairy Industry and the Food and Drug Administration; designs and specifications prepared for concrete mixers, gas engines, machine tools, vacuum tanks, air compressors, and other miscellaneous equipment.

On Buildings and Structures

The annual report for 1916 records surveys made and sewer grades staked for the Bureau of Animal Industry at an experimental farm at Beltsville, Maryland. The report for 1917 records several such services, including the making of plans for a sewage-disposal system at the Marine Corps Barracks at Quantico, Virginia, and a score of separate pieces of work covering building plans, laboratory equipment, and experimental apparatus.

In the annual report for 1918, it is recorded that a combined storm-water and sanitary sewer had been designed for the Arlington Experiment Farm of the Bureau of Plant Industry. Complete plans and specifications had been prepared for a color laboratory of the Bureau of Chemistry at Arlington Farm (p. 391) in 1919, and its construction supervised. In 1919, drawings for a milk station, creamery, and cheese factory were made for Animal Industry, and a garage, shed, greenhouse, and residence for a Plant Industry station in Arizona. Help was given on design and construction of a manure pit at the U. S. National Soldiers' Home. In

1920, studies were made for water supply, drainage, and sewage disposal installations at the new plant-detention station of Plant Industry at Bell, Maryland, and for sanitary facilities at the Arlington Farm (50—1920:427).

In the next decade a similar record runs. The services rendered range from the designing of simple apparatus to complete plans and specifications for laboratory buildings and other structures. A large portion of the time of the Structures Section was required by these coöperative services. One of the services mentioned was the planning and supervising of the installation of a drainage system for a pecan orchard in Lee County, Georgia, upon which the Bureau of Plant Industry was carrying out some of its experimentation.

In four years, from 1930 to 1933, items of service in the design and erection of buildings were rendered as follows by the Division and Bureau of Agricultural Engineering to other Bureaus of the Department of Agriculture and to other Executive Departments, including Interior, Post Office, State, and Treasury. For the Bureau of Agricultural Economics and the Bureau of Agricultural Engineering, a cotton-ginning laboratory was designed and built for the investigations conducted coöperatively at the Delta Branch Experiment Station, Stoneville, Mississippi. For the Bureau of Animal Industry, plans and specifications were prepared for a zoological laboratory, a poultry laboratory, a poultry-fattening and -feeding station, and a building for housing small experimental animals, all at the Animal Husbandry Experiment Farm at Beltsville, Maryland.

For the Bureau of Chemistry and Soils, plans and specifications were made for two residences on the Naval Stores Station at Lake City, Florida. For the Bureau of Entomology, similar services were rendered on a head house to be constructed on the Arlington Experiment Farm near Washington. For the Food and Drug Administration, plans and specifications were prepared for a greenhouse at Heddon Heights, New Jersey. For the Forest Service and the Bureau of Public Roads, three buildings, comprising offices, shops, and storage facilities, were designed, and specifications prepared for their erection, at Vancouver, Washington. For the Forest Service and the Bureau of Public Roads, and for the U. S. Coast

Guard of the Treasury Department, plans and specifications were drawn for a group of fourteen buildings, including an administration building, barracks, warehouses, machine shops, garage, etc., to be built on Government Island, in the estuary at Oakland, California.

A similar wide range of services was rendered in the design and installation of structures other than buildings. Some of those rendered during the last four years are listed below. Calculations were made to determine the capacity of seven different boiler plants, and specifications made for four temperature-control systems for four different Bureaus. Calculations were made and wiring layouts were prepared for two high-tension electrical distribution systems, and specifications of electrical installations were made for various field stations of the Department of Agriculture. Specifications were drawn also for refrigerating, heating, plumbing, ventilating, sewerage, and drainage installations on numerous field stations. Typical layouts of canning centers were prepared for the Bureau of Home Economics. Designs were made for cold-storage rooms and for the remodeling of heating systems, and, finally, an eagle flight cage was designed for the National Zoölogical Park. Similar services were rendered to other Federal Executive Departments, including Interior, Post Office, State, and Treasury.

WAR COÖPERATION IN RURAL ENGINEERING

In times of war, powers are exercised by administrative agencies which ordinarily are not given to them in times of peace. Also, objectives are determined and pursued with energy during the stress of war emergency which sometimes are overlooked or neglected when emergencies lapse. For these reasons it seems desirable to discuss the reported war-time activities (50—1918:392, and 1919:417-20) separately from those in normal times.

The Division of Agricultural Engineering rendered assistance to the Federal Board for Vocational Education in connection with the industrial education of soldiers, and also coöperated with the War Department in similar activities. Plans, also, were prepared for the instruction of men in the American Expeditionary Force overseas who expected to take up farming for a livelihood when they returned to America.

The Chief of the Division of Rural Engineering was a member of a Departmental Committee on Farm-Implements Control appointed by the Secretary of Agriculture. After the close of the war all control activities were turned over to the Division of Rural Engineering, which continued these operations during 1920, including the issuing of licenses. In collaboration with the Conservation Division of the War Industries Board, work was done on the standardization of farm implements.

Throughout the war, the Division coöperated fully with the United States Food Administration in promoting grain conservation. Here, engineering activities were centered in improved operation of grain separators to prevent the wasting of grain through leaving it in the straw. After the termination of the work of the Food Administration, the Division developed coöperation with the extension forces of the State Relations Service. Schools for threshermen were organized, the Division outlining the courses and giving talks and demonstrations on thresher-operation to threshermen and farmers. More good was accomplished through these schools than by trying to supervise threshing operations.

The Federal-State coöperative Agricultural Extension Service, through its hundreds of county agents, coöperated with other official agencies in war-time activities concerned with farm implements. They aided the Federal Trade Commission in a survey of the prices of farm machinery. For the Council of National Defense they obtained reports from owners of grain separators and aided in the inspection of threshing operations and in the routing of grain separators to serve communities with the least loss of time. For other official agencies, including the War Industries Board, they made surveys of the increased use of farm machinery, including the use of tractors on farms, and promoted a campaign for a standard width of farm vehicles (51—1919:377-79).

Plans for farm structures were sent to the heads of the American Expeditionary Force in France for use in the reconstruction of war-devastated areas. From August, 1918, to March, 1919, the principal architect of the Division of Rural Engineering was detailed to the Building Materials Division of the War Industries Board to assist in the preparation of standard specifications and details for building construction.

EXTENSION ACTIVITIES IN RURAL ENGINEERING

The Divisions charged with different lines of agricultural engineering, like other subject-matter units, both Federal and State, take an active interest in extension activities in their fields. This has been especially true, and indeed necessary, of agricultural engineering, because of its comparative newness. Relatively few of the regular extension forces had had previous training in engineering. In the half dozen years following the transfer of the Federal work in agricultural engineering to the Office of Public Roads and Rural Engineering in 1915, a large volume of coöperative activity was developed by direct agreement with the States concerned, and not through the Agricultural Extension Service which began to function as a national setup in the same year. During this early period, appropriations for extension enterprises were made by Congress direct to the subject-matter Bureaus and Divisions. From about 1920 onward, however, Congress limited expenditures of funds for extension work by subject-matter units. At that time the Division of Agricultural Engineering was maintaining co-operation under signed agreements with numerous States, including Alabama, Arkansas, Georgia, North Carolina, Tennessee, West Virginia, and Wisconsin, in drainage extension alone. These agreements were discontinued and all activities continued through the regular Federal and State extension agencies. Discussions of all of the extension work in agricultural engineering conducted in the fiscal years 1922 and 1923 were published (30—270 and 344) in 1924 and 1925, respectively.

A minor amount of teaching was done in the early part of this period. In 1917, for instance, a Division representative had given a course of lectures on tile drainage at the Georgia College of Agriculture. In the same year, also, a representative of the Division of Rural Engineering attended a farmers' short course at Iowa State College and delivered a series of lectures on farmstead planning (50—1917:379).

In the past two or three years the Bureau of Agricultural Engineering has enlarged its extension activities, all of which are promoted collaboratively with the Federal-State coöperative Agricultural Extension Services. The effort is directed toward the two

ends of lowering production costs on farms and making farm and farm-home life and work less difficult and more attractive. The extension activities may be classified under four heads, as follows:

1. Improvement of fields by means of terracing, drainage, irrigation, and the removal of obstructions and barriers.
2. Utilization of labor, power, and equipment for the production of high-quality commodities at low cost.
3. Building-plan service to provide alteration and construction recommendations in conformity with the storing, housing, and dwelling recommendations of the extension services of the States.
4. Home-improvement plans and engineering technical aid in coöperation with home economics projects to raise the level of farm home life.

For the year 1933 it was reported, among other extension activities, that more than 40,000 machines were repaired, and nearly 29,000 farms used better machinery practices, through extension-engineering recommendation. Building were erected on more than 50,000 farms, and home and home-utility improvements reported in excess of 14,000 items. In spite of financial difficulties, nearly 1,500,000 acres were terraced on over 44,000 farms under extension supervision, making a total of nearly 13,000,000 acres on 400,000 farms so terraced in conformity with official recommendations during the last ten years. Improvements in equipment or practices were made on a total of more than 150,000 farms during the year.

The publications listed in the Literature Cited at the end of this chapter which have been cited in this section on the Introduction are Nos. 1b, 5, 8, 9, 10, 11, 12, 16, 21a, 21b, 26, 27, 28, 29, 30, 31, 32, 34, 36, 37, 39, 40, 41, 42, 43, 44, 45, 46, 48, 49, 50, 51, 54, and 57.

2. IRRIGATION ENGINEERING

THE ACTIVITIES IN IRRIGATION ENGINEERING are of several different sorts. They require surveys for water sources, reservoir sites, and irrigable areas. They are concerned with irrigation structures, such as dams, reservoirs, and canals and ditches with their attendant structures, and they may include power engineering also. They cover water conservation, including watershed protection, erosion prevention to prevent silting of reservoirs, water spreading or artificial methods of inducing percolation, and studies of water runoff,

seepage, and evaporation. Finally, they include studies of the water requirements of crops, and of proper methods and times of applying the required or available water supply to fields.

It is obvious that most of these different activities of irrigation engineering have to do with the conservation and use of water. Only those dealing with water requirements or the duty of water, and with the methods and times of applying that water, are truly concerned with agriculture. Most of these latter really are not engineering problems but belong more properly to plant industry. Indeed, in actual practice they are investigated commonly by agronomists rather than by engineers. Therefore, as noted in the introduction to this chapter on *Agricultural Engineering*, the major discussion of irrigation engineering is reserved for the chapter on *Water Resources*, in the volume on *Natural Resources*. The more clearly agricultural aspects of the subject have been discussed in the chapter on *Plant Industry* in the present volume.

3. DRAINAGE ENGINEERING

DRAINAGE IS PARTLY A PROBLEM of agriculture and partly a problem of natural resources. In agriculture, it is primarily a problem of engineering, but with a wide outreach into economics and plant industries. In natural resources, it is partly a problem of the reclamation of the public domain and partly a problem of wild-life conservation. In both, it is an integral part of the national, regional, and State problems of land-use planning.

SCOPE OF THE ENGINEERING PROBLEMS

Drainage problems fall naturally into three separate classes. First are those of swamp and overflow lands, both stream and tidal overflow being involved. Second are those of irrigated or seeped lands. Third are those concerned with the prevention of soil erosion.

In the eastern United States, east of the one-hundredth meridian, there were, some thirty years ago, about 77,000,000 acres of swamp and overflow land of three different kinds. First, there were lands too flat to have good natural drainage, such as prehistoric extensions of the beds of present lakes. Secondly, there were valley lands, subject to periodic overflow by streams. Thirdly, there were extensive tidal marshes along ocean and bay shores.

Where natural outlets occur, the problems of drainage are those of the individual landholder. Where artificial outlets must be provided for lands naturally poorly drained—the first class mentioned above—or where extensive and expensive levees or drainage channels must be built, as on fresh-water overflow or tide-marsh lands, the problem requires the coöperation of many individuals and agencies. In such cases, it is customary to organize levee districts, drainage districts, reclamation districts, and similar public bodies, under the laws of the interested States. While the States in general have regulated the organizing and financing of these types of administrative districts, they usually have not furnished such districts with the necessary technical information to insure adequate engineering structures or sound financial policies. To this fact was due the increasing demand on the Federal Department of Agriculture for technical assistance (39—1907:705).

In irrigated areas, two kinds of drainage problems may present themselves, as irrigating proceeds to higher and higher levels in a given valley or area. The first problem is that where the land already has become flooded and often has become alkaline. The second problem is that of lands where the water table has risen enough to interfere with crop production. Naturally, the lowest lying lands, often the most valuable and most improved, are the first to be destroyed by seepage and flooding. At the same time, the water table rises destructively on lands of somewhat higher elevations. The pioneer settler, therefore, is most likely to be the one to suffer severe property losses from the development of later projects encouraged by State or Federal Government as wholly desirable from the standpoint of agricultural and other economic development. In Italy legislation was enacted long ago, compelling the action necessary to prevent the damage from flooding and alkali concentration caused by seepage waters (41—192).

Still a third class of drainage problems has to do with the prevention of soil erosion. In the older settled parts of the east, and especially from the Ohio Valley southward, soil erosion had assumed alarming proportions even thirty-five or forty years ago. Rolling topography, clay soils, relatively heavy rainfall occurring throughout the year, little or no protection through the freezing of the soil in winter, and the dominance of crops planted in widely spaced

rows and cultivated between the rows, provided ideal conditions for rapid removal of surface soil by erosion. It was held possible that the proper use of tile drains might prevent at least a portion of this injury.

The increasing frequency of problems such as those outlined above has made drainage investigations one of the most important divisions of agricultural engineering.

HISTORICAL DEVELOPMENT

In 1850 the Congress granted to most of the States the swamp and overflowed lands from the public domain lying within their borders. This was done for purposes of State reclamation by levees and drains, with special provisions for California, Minnesota, and Oregon. This legislation brought the problems of drainage acutely before many of the States within the next ten or twenty years. State Engineers, State Surveyors, or State Commissions of Reclamation were charged with administration.

Only a few of the State agricultural experiment stations gave attention to drainage problems before 1900. The Arkansas, California, Oregon, and Rhode Island Stations issued bulletins on drainage in the years from 1893 to 1898. No coöperative relations appear to have developed during this half century other than those involved in the transfer of Federal land to State ownership.

The study of drainage problems grew out of injury to irrigated lands in the West, caused by overflow or seepage of water from irrigation ditches and irrigated fields at higher levels. This condition resulted in the swamping of lowlands, or in a rise of the water table immediately harmful to the roots of crop plants and causing a deposit of injurious alkali salts on the surface. The study and correction of this problem was held to be a proper activity of public agencies because both Federal and State governments were encouraging the expansion of irrigated areas from lower to higher lands. The unfortunate owner of lower lands was penalized, therefore, through no fault of his own and partly because of the action of public agencies.

From studies of such lands, the investigations of drainage problems progressed to overflowed lands along streams, to swamp lands, to tidal marshes, and to the possibilities of preventing through

underdraining the destructive erosion of hillside lands. Some of the surveys of drainage problems and subsequent plans for drainage projects were made at the request of private owners. Some were made at the request of officers of drainage districts, and some were carried out in coöperation with county commissioners or supervisors, State agricultural experiment stations, or the Office of State Engineer.

Attention to drainage problems by the United States Department of Agriculture dates from the year 1900. The Office of Experiment Stations had begun coöperative investigations of irrigation problems in 1898. Drainage investigations grew naturally out of the problems encountered in its study of irrigation conditions. As early as 1900 the Division of Irrigation Investigations reported that a study of drainage problems was needed, especially in the swamped portions of irrigated areas, and that these studies should be made by the Federal Government (39—1900:209). In 1901, the Division reported that many midwestern States were studying drainage problems, that it had been asked to assist in such studies on irrigated lands, and that a compilation of State laws should be made and published (39—1901:230—31). The report, also, of the Secretary of Agriculture for the same year made mention of these problems and of the requests upon the Department for assistance.

In 1902 the investigation of drainage problems was begun, partly in coöperation with the State Engineer in Colorado. In 1904, the name of the Division in the Office of Experiment Stations was changed from Irrigation Investigations to Irrigation and Drainage Investigations. In 1905, the work of the Office in both irrigation and drainage was presented before the House Committee on Irrigation of Arid Lands (42—63). In October, 1907, Drainage Investigations was made a Division of the Office, coördinate with the Division of Irrigation Investigations. In 1909, the organization, work, and publications of the Division were set forth (32—88), with a revision in 1910. In about 1911, field headquarters were established for most members of the investigating staff of Drainage Investigations. Some of the field men had charge of the work in a single State, whereas others had charge of larger districts (40—1911). The work continued to grow on an increasing scale until both irrigation and drainage activities were transferred on July 1,

1915, from the Office of Experiment Stations to the newly created Division of Rural Engineering in the Office of Public Roads and Rural Engineering.

In 1902 and especially in 1903, intensive independent studies were made of drainage problems in the Fresno district of California, in the Yakima and the Atanum Valleys in Washington, in the Greybull River Valley of Wyoming, in the Missouri River Valley of Iowa, and in the glacial swamps of north-central Iowa. In addition, an experiment in Georgia and preliminary studies in Florida were made to prevent hillside erosion by means of underdrains (41—147). Apparently, there was no coöperation with any other official agencies in the conducting of these investigations. They are mentioned merely to show the wide geographic extent of the studies from the very beginning. It was noted (*op. cit.*, p. 62) that new drainage laws had been enacted in Arkansas, California, Idaho, and Nebraska, and amendments added in ten other States. The investigations made in the fiscal year 1904 were of similar character, but more numerous and extensive geographically (41—158: 643—743). The results of the continuing experiment in drainage control of hillside erosion are presented (*op. cit.*, pp. 728—31). Co-operative studies of drainage problems, also begun in 1902, are discussed a little later in this section.

The drainage work developed rapidly, and by the end of the first ten years, in 1912, studies had been made in more than half of the States, and several projects had been completed in those States having the largest areas of land needing drainage, or the most acute drainage problems in connection with irrigation. In the early years much attention was given to a study of drainage laws in this country and abroad (41—192), and to assisting the different States in drafting adequate legislation for the organization of drainage districts. Help was given also to groups of farmers in completing the organization of such districts after such action had been authorized by State law.

Yearly summaries of the work done are found in the *Annual Report of the Office of Experiment Stations* (40), 1902—12; in the *Reports of the Director of the Office of Experiment Stations* (39), 1904—14; and, in still more abbreviated form, in the *Report of the Secretary of Agriculture* (26) for the same years. A comprehensive

technical report was published for the year 1903 as *Bulletin No. 147* of the Office, under the title "Report of Drainage Investigations, 1903," and a similar comprehensive combined report of both Irrigation and Drainage Investigations for 1904 was published as *Bulletin No. 158* of the Office (41—158). Thereafter the detailed data on individual projects appeared in bulletins (41) or circulars (42) or as special papers in the technical *Annual Report of the Office of Experiment Stations* (40).

Besides the publications hereinafter mentioned, which contain the results of coöperative drainage activities, the Office of Experiment Stations published numerous bulletins (41—198, 230, and 234) and circulars (42—50, 57, 86, 103, and 113) which contained similar data obtained without coöperation.

Several *Department Bulletins*, published from 1913 to 1915, after the series of Bureau and Office publications were discontinued, contain results of drainage surveys made independently by the Division while still in the Office of Experiment Stations. Among these were results obtained in Louisiana (28—71 [and 652, a later revised edition]), and in South Carolina (28—114), as well as a general discussion of the drainage of irrigated lands (28—190) published in 1915.

Early Coöperation in Drainage Studies

It is interesting to note that Federal-State coöperation in drainage investigations began in 1902, the first year in which any studies of this subject were made by a Federal agency. In that year the Division of Irrigation Investigations of the U. S. Department of Agriculture, which already was coöperating with the State Engineer of Colorado in a study of irrigation problems, broadened the coöperation to cover a study of drainage of swamped lands in irrigated areas. The collaboration has increased steadily from that time.

Early Federal interrelations.—The casual and infrequent relations with other Federal agencies were more in the nature of services rendered than of true coöperation. In 1904, a preliminary study of possible drainage of the Florida Everglades was made in coöperation with the Federal Bureau of Plant Industry (41—158:644).

In 1910, during a coöperative survey of the Fifth Louisiana

Levee District, minor coöperative relations were established with the Mississippi River Commission and the Corps of Engineers of the War Department (42—104). In the same year some assistance was given the Yakima Indian Reservation in Washington on drainage problems (40—1910). In 1911, the Office joined the Bureau of Animal Industry of the Department of Agriculture in drainage operations on the Beltsville Experiment Farm and the Bureau of Plant Industry on its Arlington Experiment Farm (40—1911:41).

Investigations were made jointly with the Bureau of Standards on the durability of cement tile in alkali soil. These were continued until the transfer of the work to the Office of Public Roads (39—1915:310).

Early Federal-State coöperation.—The Federal Office of Experiment Stations, through its Division of Irrigation Investigations, as previously noted, began drainage studies in coöperation with the State Engineer of Colorado in 1902. In the following year it began official coöperation with the Utah Agricultural Experiment Station, and in 1904 with the Indiana and Iowa Stations. In these same early years coöperation was begun with the officers of counties and drainage districts in various States, and also with private landowners.

Beginning in 1904, the drainage experts of the Office of Experiment Stations aided various State agricultural colleges in planning courses of instruction in drainage engineering. It was reported that in that year Illinois University had forty-two students and Iowa State College had sixty-five students enrolled in such classes (26—1904:109). The Office also helped the State agricultural experiment stations in planning drainage experiments, even though the studies were not to be conducted coöperatively.

Arkansas: In 1910, the Office of Experiment Stations collaborated with the State Normal School in drainage operations to improve the School Farm (40—1910). During 1911 and 1912, the Cypress Creek Drainage District coöperated in an extensive survey of their area and paid half of the expenses. The report was published (28—198) in 1915. Earlier preliminary surveys had been made by the Office of Experiment Stations in 1906 and by the Mississippi River Commission in 1907, before the drainage district was created.

California: In 1902, the Office of Experiment Stations began a survey of drainage problems on irrigated land in the vicinity of Fresno. The rapidly rising water table already had destroyed valuable vineyards, and was threatening other wide areas. This early work, growing out of cooperative irrigation investigations, was not itself cooperative. The results were presented in three separate publications (41—147; 42—50 and 57). In 1906, the Office began cooperation with the State Engineer on this drainage project. With aid from the Fresno farmers concerned, tile drains were laid on a forty-acre tract and pumps installed to lift the collected drainage water back into irrigation canals (39—1907:711). Similar works were put through near Modesto and Turlock, in cooperation with drainage districts. These studies were continued for a few years, and the cooperative results published in 1909 (41—217). Later investigations were begun in cooperation with the California Agricultural Experiment Station to determine the efficiency of underdrains in the removal of alkali. This study was continued until the transfer of Drainage Investigations to the Bureau of Public Roads in 1915 (39—1915:310).

Colorado: The first State with which cooperation in drainage experiments developed was Colorado. In 1902, cooperation was begun with the State Engineer, with whom there had been active relations in irrigation investigations for some years. Studies were directed toward the adequate drainage of waterlogged irrigated lands.

Delaware: In 1909, the Division of Drainage Investigations made a survey of the tidal marshes of the Atlantic Coast and of the possibilities of their reclamation (41—240). On the two projects within the State, assistance was received from the director of the Delaware Agricultural Experiment Station (*op. cit.*, p. 3).

Florida: In 1905, the Florida legislature created a State Board of Drainage Commissioners to engage in the construction of drainage canals, primarily in relation to the famous Everglades swamp. The Board immediately asked the cooperation of the Office of Experiment Stations (40—1905:208). The Office already had made a preliminary survey in cooperation with the Federal Bureau of Plant Industry in 1904. Work in collaboration with the State Board, to determine the most feasible drainage outlet (39—1907:

712), was begun in 1906, and the results were scheduled at one time to be published as *Bulletin No. 218* of the Office of Experiment Stations. Because of complications arising from commercial exploitation in the attempted sale of Everglades lands by private speculators, the Federal publication never was issued.

Georgia: Numerous studies were made in this State by the Office of Experiment Stations in the four years beginning with 1908. There was coöperation with the Georgia Geological Survey in part of this work, and the results were published by the Survey in its *Bulletin No. 25*, under the title "Drainage Examinations and Surveys in Georgia Conducted by Drainage Investigations, Office of Experiment Stations, United States Department of Agriculture, 1908-1911." This title was preceded by an introduction by the State Geologist, entitled "The Drainage Situation in Georgia." The coöperation was abundantly shown on the title page. This coöperation was continued.

In 1911, the Georgia Legislature passed a drainage law, following which drainage districts were organized. In *Georgia Geological Survey Bulletin 32*, published in 1917, and entitled "Agricultural Drainage in Georgia," a list of forty of these drainage districts is given. Discussions of characteristic drainage problems of different sections are presented, together with reports on typical drainage districts, and the observation that, considering the total area needing drainage, about one sixty-eighth of the work had been begun. The first part of this bulletin, discussing drainage surveys and districts with their respective problems, was by the Division of Drainage Investigations of the Office of Public Roads and Rural Engineering, of the U. S. Department of Agriculture, while the second part, dealing with undrained portions of the State, was authored jointly by the Federal Division and the State Geological Survey.

Iowa: Drainage investigations in Iowa in coöperation with the State Agricultural Experiment Station were begun in 1904 (41-158:20) and completed in 1906. In addition to experiments in land drainage, they included studies of excavating and pumping machinery. These were included in a more comprehensive paper published (42-74) in 1907. Later, the Office coöperated with the Iowa Drainage, Waterways, and Conservation Commission in a survey of drainage possibilities in the valley of the West Fork of the Des

Moines River. The results were published in the report of the State Commission for 1910.

Indiana: In 1904, a study of drainage problems in Indiana was begun in coöperation with the Agricultural Experiment Station of Purdue University. A preliminary examination of drainage conditions in the valley of the Kankakee River was made in 1904 and 1905 (40—1904:516, and 1905:485; 41—158 and 645). In 1906, an agreement was made between the Office of Experiment Stations and the four Indiana counties concerned to survey and locate a new channel for the river through Indiana and into adjacent Illinois for a distance of about eight miles. A committee of citizens known as the Kankakee Drainage Committee was formed, and through it the four counties coöperated by furnishing all the labor necessary to assist the Federal engineering force. The study was completed in 1906 and the report submitted to State and county authorities. In 1909, the report was printed by the Office (42—80). Similar coöperative studies were made in Wisconsin in 1904 (42—158:21).

Louisiana: Coöperative surveys and drainage plans were made with the Fifth Louisiana Levee District and the results published by the Office (42—104). There was minor coöperation also from the Engineer Corps of the United States Army and from the Mississippi River Commission. Much investigation conducted later in the State was independent, apparently, of other official agencies (28—71 [and 652, a later revision]).

Minnesota: The Northwest Experiment Station at Crookston, a branch of the State Agricultural Experiment Station at St. Paul, was tiled in 1906 as a drainage experiment coöperative with the Federal Office of Experiment Stations (40—1906:40).

Mississippi: In 1907 and 1908, swampy portions of the Yazoo Delta in Bolivar County, Mississippi, were surveyed by the Division of Drainage Investigations. Financial help was received from the Drainage Commissioners of the County, and from local land owners. The results were published in 1909 (42—81). The Belzoni Drainage District in Washington County, Mississippi, was organized under a special act of the Mississippi Legislature which also provided for coöperation by the Belzoni Commissioners with the U. S. Department of Agriculture in making the survey and plans.

The Office of Experiment Stations agreed to the plan and the work was done in 1910, with \$2000 contributed by the Commissioners of the Drainage District (*op. cit. infra*, p. 9), to whom the report was submitted (41—244). In 1913, a survey was made of the lands in the Big Black River Drainage District, the district sharing the expense (28—181). Extensive data were included from the river-gaging station of the U. S. Geological Survey near Jackson and from the records of several U. S. Weather Bureau stations in the District. In 1913, and probably earlier, the drainage engineer of the Mississippi Agricultural Experiment Station was maintained in coöperation with the U. S. Department of Agriculture, according to the staff list on the inside of front covers of the station bulletins. This statement disappeared in 1915.

Nebraska: In 1905, experiments in draining a thirty-acre tract near Lexington were begun. The expenses were borne from an appropriation made to the State Agricultural Experiment Station, and an allotment made by the Office of Experiment Stations (40—1905).

North Carolina: In a study made in North Carolina in 1910, similar to those in Mississippi, the drainage district involved, along with some private land-owners, coöperated in furnishing the services of an engineer and the labor needed by the combined technical forces (41—246). At about the same time, coöperative drainage surveys were made on three substations of the North Carolina Agricultural Experiment Station (40—1911). At about this time, coöperative agreements were made with the State whereby the U. S. Department of Agriculture stationed a drainage engineer in North Carolina, the State Department of Agriculture, which coöperates in maintaining the Experiment Station, furnished an assistant engineer, and the two joined in promoting drainage practices in the State. A bulletin (20—234) issued in 1915 on farm drainage resulted from this coöperation, as stated in a footnote therein.

In January, 1914, the North Carolina Station began to include the names of Federal coöperating workers in the list of station staff inside the front cover of its bulletins (20—224), the list thereafter including one drainage engineer from the U. S. Office of Experiment Stations.

North Dakota: One of the most extensive early coöperations of

the Office of Experiment Stations in drainage investigations was conducted in North Dakota in 1905 and 1906. In January, 1905, the Second State Irrigation Convention of North Dakota requested the Office to give help on State drainage problems. The Office, in turn, through the North Dakota Agricultural College, proposed to the interested counties in the Red River Valley a coöperative topographic survey of the drainage needs. Inquiries made of the owners of 30,000 acres of land showed complete crop losses on more than one-tenth in 1905, because of floods. The counties agreed to bear half the expense, and the State Engineer's Office to contribute the services of one assistant engineer. The coöperative investigation was made in four counties in 1905 and in one county more in 1906. The total expenses were about \$10,700, of which the counties contributed approximately \$3000; the State Engineer's Office, \$1300; the Great Northern Railway, \$900; and the Office of Experiment Stations, \$4000, with an additional \$1500 to cover the cost of printing the report (41—189) which was issued and submitted to the State authorities in 1907. In 1906, the experiment farm of the North Dakota stations was tile-drained as a coöperative experiment by the State and the Office of Experiment Stations (40—1907: 713).

South Carolina: Experiments in the drainage of overflowed lands near Charleston were begun in 1906 by the Office of Experiment Stations in coöperation with the Sanitary and Drainage Commissioners of Charleston County (40—1906:42).

Tennessee: In 1910, the Office of Experiment Stations entered into an agreement with the State Geological Survey to conduct a survey of certain drainage problems. The results were published by the Survey (40—1910).

Texas: In 1912, the county commissioners' court of Jefferson County agreed to provide half the cost of a drainage survey of that county, and of the preparation of drainage plans. Work was done in the same year, and the preliminary results published by the Office of Experiment Stations immediately, and the complete data (28—193) in 1915.

Utah: In 1903, the Office of Experiment Stations began coöperation with the State Experiment Station in an examination of swamped lands lying below the irrigation ditches in Cache, Emery,

and Washington Counties. Coöperative experiments were begun in Cache County on the removal of surplus water from swamped and alkaline tracts and in the growing of crops on lands thus drained. Ground-water wells, also, were sunk in order to determine the effect of irrigation on fluctuation of the water table during the season (39—1904). These experiments were continued during 1904, were proved successful, and were extended in 1905 (39—1905:486; 40). In 1904, the Office furnished the draintile and the landowners bore the expense of laying it. Beginning with the fiscal year 1906, a State appropriation of \$10,000 was made available to the Experiment Station for irrigation and drainage studies with the understanding that the Office of Experiment Stations would provide an equal amount. Of this State sum, \$4000 was allotted to drainage investigations, and Professor W. W. McLaughlin, then on the staff of the Utah Station, was placed in charge of the coöperative project (40—1905:205). Thereafter, the Station paid half of the expense of these reclamation experiments, the benefited farmers and communities furnished labor and bore another portion of the expenses, and the Office of Experiment Stations contributed the rest of the cost (39—1907:713).

In their summary of fourteen years of coöperative and independent investigation, the Division of Drainage Investigations of the Office of Experiment Stations recorded several items of achievement. The first was the primary responsibility for introducing tile drainage into the cotton-belt States where State institutions, either in coöperation with the Office or independently, had undertaken the work of informing interested farmers on the advantages and methods of drainage. In the second place, from 1919 onward, at least eight States had passed general drainage laws providing for the establishment of drainage districts and for their financing through bond issues forming a lien on the benefited land. Under these laws, hundreds of drainage districts had been organized, including nearly eighty in North Carolina alone, and hundreds of thousands of acres of swamped and overflowed lands had been drained. Thirdly, the peculiar drainage problems inherent in the reclaiming of injured irrigated lands had been thoroughly studied, and satisfactory progress in their solution had been made.

At the end of the fiscal year 1915, it was recorded that manu-

scripts on the subject of tile drainage were prepared for publication as bulletins by the States of Alabama, North Carolina (20—234), and Virginia (39—1915:311). On July 1, 1915, the Divisions of Drainage Investigations and Irrigation Investigations were transferred from the Office of Experiment Stations to the Office of Public Roads and Rural Engineering.

RECENT RELATIONSHIPS IN DRAINAGE ACTIVITIES

Some physical reorganization of drainage activities took place upon the transfer of the work from the Office of Experiment Stations to the Office of Public Roads and Rural Engineering on July 1, 1915. Previously, State offices had been maintained in numerous States. In order to centralize the work more effectively, these local offices were discontinued, except those maintained under coöperative agreements with agricultural colleges or experiment stations. There also was some transfer of authority over lines of work. The project relating to drainage of irrigated lands was transferred from the Division of Drainage Investigations to the Division of Irrigation Investigations (50—1916:342), although it still remained a project in drainage engineering. While not so stated in the administrative report, it is evident from later statements that the work of investigating irrigation conditions in the humid States was assigned thereafter to the Division of Drainage Investigations. For the time being, at least, it appears that the Division of Drainage Investigations had charge of both drainage and irrigation in the central and eastern States and that the Division of Irrigation Investigations had charge of irrigation studies and the drainage of irrigated land in the western States. By 1917, irrigation in humid regions was listed as one of the major projects.

Studies of Drainage Systems

The Division of Drainage Investigations, while in the Office of Experiment Stations, had been concerned primarily with helping drainage districts, counties, corporations, and individuals solve their local problems in establishing adequate drainage facilities. With the transfer of this unit to the Office of Public Roads and Rural Engineering in 1915, more attention was given to special or fundamental problems, and less to the direct promotion of reclama-

tion. There were numerous activities, however, along this latter line in the years following 1915. In 1917, the Division published a comprehensive popular but noncoöperative discussion of methods of drainage on farms (27—805).

In 1917, the Division published a discussion of the drainage of irrigated shale lands (28—502). The study was independent of State agencies, but the analyses of the water samples were made by the Water Laboratory of the Bureau of Chemistry, as stated in a footnote. In the same year, a report on the agricultural drainage of Georgia was prepared in coöperation with the State Geological Survey for publication by the State (50—1917:378).

In 1919, a coöperative study of the effects of tile drainage in the prairie section in Alabama was completed. This study was published by the Alabama Experiment Station (1a—214) in 1920. A similar comprehensive manuscript was prepared on farm drainage in West Virginia, to be published by the College of Agriculture of that State. Organization of the first drainage district in Alabama proved that the State law was unsatisfactory, whereupon assistance was given the State in rewriting the act to simplify procedure and to secure the bond issues more completely (50—1923:480).

In 1925, the Division began coöperative studies to determine proper design of tile-drain systems in depth, spacing, water-table relations, etc., on the Experiment Farm at Stoneville, Mississippi, and in Illinois at the Agricultural Experiment Station at Urbana.

In 1929, the Division, in collaboration with the Federal Forest Service and several State agencies, made a study in northern Minnesota on the growth reaction of swamp forests to drainage operations on the lands they occupy.

In 1932, the Division of Drainage Investigations, in coöperation with the Florida Station, began experiments on methods and costs of controlling ground water in peat and muck soils on a tract near Belle Glade. In 1933, equipment was installed, different types of drains constructed, and the height of the water table determined by wells.

In 1933, in coöperation with the Utah Experiment Station, investigation was made in draining land overlying an artesian ground-water reservoir by means of pumping from wells in deep

surface drains. The results were prepared for publication by the Station (52—242).

In 1916, the Division of Drainage Investigations was asked for assistance on a comprehensive study of the drainage problems of the Red River Valley in Minnesota, North Dakota, and South Dakota, in coöperation with the States. This followed some preliminary, and more local, coöperative investigations made several years before. The proposal was agreed to, provided that financial help from the States could be supplied. Through the active interest of the North Dakota Flood Control Commission, a fund of \$2000 was made up in 1918 by eight county boards, and the coöperative study was made in the three years from 1918 to 1920. Progress reports were furnished to the States from time to time, and a comprehensive report published (28—1017) in 1922. Assistance was acknowledged therein (p. 89) from State engineers, State agricultural colleges, county officers, and city engineers, including various official agencies in Manitoba, Canada.

Questions having been raised as to the possible effects of tile drainage on soil temperatures and therefore on the crops growing on such soils, the Division of Drainage Investigations undertook pertinent studies. These were begun in coöperation with the Georgia State College of Agriculture on its farm at Athens in 1921, and in 1922 on the Summerland Coast Experiment Farm of the South Carolina Station in coöperation with Clemson College. Temperature changes were found to be unimportant.

Drainage Surveys

In coöperation with the Michigan Geological and Biological Survey, the Federal Division of Drainage Investigations undertook a survey to determine the extent of the drainage undertaken in Michigan, together with its costs and results, and to plan the legislation necessary to the effective reclaiming of the remaining area (50—1919:416). This study was published by the Michigan Survey in 1919. In order to determine the progress of drainage activities in the three years from 1920 to 1922, the Federal Division asked the officials of each county in the southern, central, and western States for the number and area of drainage districts and the cost of improvement undertaken (50—1923:479).

In coöperation with the Federal Bureau of Agricultural Economics, the Division made a reconnaissance survey of land reclamation and land settlement in all the southern States from Maryland to eastern Texas. This was begun in 1923, and the results were designed to serve as a base for interbureau planning of studies of engineering problems (50—1923:479). In 1924, the Bureau of Agricultural Economics compiled extensive data on land-reclamation policies in the United States (28—1257), including statistics of reclaimed lands. The manuscript was examined and recommended for publication by the Committee of Special Advisors on Reclamation appointed by the Secretary of the Interior.

Status and Finances of Drainage Districts

During the War, the Federal Government created a Capital Issues Committee to supervise the issuance of bonds and securities. The Division of Drainage Investigations coöperated with this Committee by investigating the status of all drainage districts that requested approval of proposed bond issues. In 1918, twenty such projects, affecting about 7,000,000 acres and involving issues totaling \$14,700,000, were investigated. In 1919 twelve more projects were studied.

In 1924, the Division published the results of a comprehensive independent study of drainage-district assessments (28—1207). It included a discussion of current practices in assessing benefits under the various State drainage laws. The contained data were derived from the officers of such districts and from State officials, though the publication does not so declare. Similar studies of the physical and financial status of drainage districts in the southern States in 1926 were made in 1928 by the Division in coöperation with the Bureau of Agricultural Economics. These studies followed heavy money losses by the promoters, and by the buyers of both land and bonds. The coöperative results were published (29—194) in 1930.

A popular discussion of the organization, financing, and administration of drainage districts was published (27—815) in 1917 by an economist employed by the Drainage Division.

By 1924, the depression in agriculture and the high cost of fuel and labor for pumping had caused financial difficulties to drain-

age districts in the upper Mississippi Valley. The Division of Drainage Investigations, with assistance from district and State officers, collected data on the cost of operating drainage pumping plants in a selected area along the Illinois River and the adjacent Mississippi River. The studies were continued from year to year as conditions became progressively worse. By 1930, five annual progress reports had been issued. The data on cost of pumping and also on design and operation of pumping plants then were accumulated for the five-year period and published (29—327) in 1932. These studies have been continued in Illinois, and have been extended into Iowa, Minnesota, and Missouri. Many drainage districts were found to have drained their lands successfully and to have paid their obligations. Many others had failed in one or both respects. For each district studied, the Division appraised the resources and needs, and suggested plans by which land owners and security holders, through coöperation and mutual sacrifice, might rehabilitate these districts financially. These plans included the adjusting of annual payments to crop yields and prices.

Drainage Machinery, Including Pumps

The first publication issued by Drainage Investigations after its transfer from the Office of Experiment Stations to the Office of Public Roads and Rural Engineering in 1915 was a comprehensive technical discussion of excavating machinery used in land drainage (28—300). A popular discussion of the same subject (27—698) also was issued in 1915, and a new publication (27—1131) in 1920.

The second technical publication issued by Drainage Investigations after its transfer to the Office of Public Roads was a discussion of land drainage by means of pumps (28—304). This was a revision of a previous publication (41—243) designed for use in the upper Mississippi Valley. Many of the included data were obtained from drainage districts in Illinois and Iowa. In 1922, the Division of Drainage Investigations published (28—1067) a comprehensive digest of its experiments in drainage by means of pumps in Louisiana, conducted in coöperation with Tulane University from 1909 onward. Beginning in 1924, and continuing until the present time, extensive studies have been made of the cost of pump-

ing for drainage and the efficiency of operation of pumping plants in the upper Mississippi Valley, especially in Illinois, where sixty-three organized drainage districts are situated along the Illinois and adjacent reaches of the Mississippi River and 450,000 acres were reclaimed. Five annual progress reports were issued from 1925 to 1929, and in 1932 a bulletin covering the results of five years of study (29—327) was published.

The drainage of irrigated lands in the Salt River Valley of Arizona through pumping from wells was studied independently of State agencies and the results published (28—1456) in 1926.

Effect of Alkali on Drintile

In 1919, the Federal Division of Drainage Investigations began an investigation of the reported extensive failures of concrete drintile in southwestern Minnesota. The problem was important and immediate, because drainage districts had been organized to execute projects costing millions of dollars, and these investments were jeopardized. Preliminary studies in twenty-three counties determined that soil alkalis were responsible for the disintegration of the tile. Coöperative arrangements were made in 1920 with the Minnesota Agricultural Experiment Station and the State Department of Drainage and Waters to establish and maintain a laboratory at the Station for testing samples of both tile and water. The laboratory was established on July 1, 1921, and the work expanded to cover experiments in the manufacture of alkali-resistant tile. New testing methods were developed. The State Department published the coöperatively obtained information in 1921.

Coöperation was obtained from the officials of drainage districts and from commercial manufacturers of drintile. In 1923, the work was broadened to include the action of peat and muck soils, both in Minnesota and in Wisconsin, the latter in informal coöperation with the Department of Agricultural Engineering of Wisconsin University. In 1924, specially manufactured tile were buried in different soils in Minnesota, North Dakota, and South Dakota. In the meantime, the survey of damage had been extended north to the Canadian boundary. By 1926, a successful method for the manufacture of resistant tile had been developed. By 1928, the coöperative study was expanded again to include samples from

all clay-tile factories in Minnesota and part of Iowa, together with samples of Portland cement. Between 1929 and 1931, studies were begun of the effects of frost action, sulphate water, and curing temperatures on tile. Results of the studies of frost resistance were issued as a mimeographed report. In 1933, a Federal bulletin (29—358) presented the coöperative results of the study of laboratory and field tests of the action of sulphate waters on concrete tile.

Water-Flow and Runoff Studies

Important problems in drainage engineering are the effect of the nature of the drainage channel on water flow or carrying capacity, and the determinations of the actual runoff of water from affected areas, to indicate the consequent volume which must be carried by drainage structures.

Water-flow investigations.—In or before 1920, the Division of Drainage Investigations began a joint study with the hydraulic laboratory at Iowa State University on the flow of water in pipes of different kinds, such as vitrified clay, concrete, and corrugated metal. This coöperation, as it continued for several years, was expanded to include studies of the effects of different shapes of entrance edge and flared outlets of culverts and pipes, the effect of bends in channels, and the effect of the shape of obstructions, such as bridge piers, trestle timbers, piles, etc., upon velocity of flow. The coöperation included also the effect of placement of current meters and of their relation to the stream surface as influencing their accuracy. The first study covered the flow of water in drain-tile (28—854) and was published in 1920. The results of some of these studies were published by the State agency.

Studies of the flow of water in dredged drainage ditches are required in order to determine the influence of rough surfaces and obstructing vegetation on carrying capacity. The result of an independent study of such drainage structures in the Mississippi Valley was published (28—832) by the Division in 1920.

In 1931, there was published (29—269) a report on the economical use of large tile as compared with open ditches. The data were obtained through contacts with county and drainage district officials as well as private landowners in many States of the upper Mississippi Valley, though most largely in Iowa (*op. cit.*, p. 1).

In 1931 also, an investigation of ditch-cleaning methods and costs was begun in Kent County, Delaware, in coöperation with the State Highway Commission. The methods used covered hand labor, team and scraper, tractor equipment, and explosives. The study was discontinued in 1933 because of lack of funds, but a progress report was prepared.

Runoff investigations.—In 1920, an investigation of the rate of runoff from tile-drained land was begun in southwestern Minnesota, and a year later an agreement was made with the State Department of Drainage and Waters to undertake hydraulic investigations on drainage ditches in northwestern Minnesota.

After 1920, runoff investigations were gradually extended to many districts of the Mississippi Valley and its tributaries. Little mention is made of coöperation with State agencies. Runoff investigations on the Ralston Creek area in Ohio were begun in coöperation with the hydraulic laboratory in the State University of Iowa in 1922, and have been continued ever since. By 1928, it was reported that studies had been made in Arkansas, Illinois, Iowa, Mississippi, and Missouri, and were being begun in Indiana. In 1930, special stream gagings were made in collaboration with the U. S. Geological Survey because of the widespread drought of that year. The Survey itself was studying minimum stream flows in reference to water-power production and sewage disposal (50).

In 1928, the Division of Irrigation Investigations developed a plan for obtaining runoff data from drained irrigated areas in most of the western States. The information was to cover also the quantity of water applied, the structure of the soil and subsoil, proportion of total area in crop, and various meteorological data. The large volume of information already possessed by the Bureau of Reclamation of the Department of the Interior, by numerous irrigation districts, and by other agencies, was expected to be used. The Survey gathered data from nearly one hundred irrigation projects, having an aggregate area of approximately a million acres and located in thirteen western States. A report was prepared and published (29—439) in 1934.

The publications listed in the Literature Cited at the end of this chapter which have been cited in this section on Drainage Engineering are Nos. 1a, 20, 26, 27, 28, 29, 39, 40, 41, 42, 50, and 52.

4. SOIL-EROSION ENGINEERING

THE GENERAL SUBJECT of soil erosion and soil protection has been fully discussed in Section 5 of chapter 3, Soils and Soil Management (pp. 231-254). There, the engineering phases of the problem were treated incidentally as a part of the whole problem. In the present section, only the engineering phases are presented, and these only at sufficient length to make this chapter on Agricultural Engineering complete in itself.

HISTORICAL DEVELOPMENT

In the last forty years, numerous Federal and other research agencies have pointed out the magnitude and wide distribution of the erosion processes and the economic importance of their destructive effects. These agencies have included the U. S. Geological Survey, the U. S. Department of Agriculture, the U. S. Industrial Commission, the Conference of State Governors, the National Conservation Congress, the Engineer Corps of the United States Army, and several State agricultural experiment stations. Some thirty to twenty years ago, several agencies of the U. S. Department of Agriculture, including the Bureau of Soils, the Forest Service, the Office of Experiment Stations, and the Weather Bureau, began investigations of the causes of erosion and of methods for their control. As early as 1912, the Forest Service and the Office of Experiment Stations collaborated in constructing a working erosion model for schools (42-117). We are concerned here with the engineering studies made by the Drainage Division of the Office of Experiment Stations and cooperating agencies.

As early as 1903, the possible function of drainage as a means of controlling destructive soil erosion was recognized by the engineers of the Irrigation Division of the Office of Experiment Stations (40-1903:313) of the U. S. Department of Agriculture (26-1903). In that year preliminary studies were made in Florida and a noncoöperative experiment was started in Georgia to prevent hillside erosion by means of underdraining. These studies were continued through 1904, the results were published (41-158:728-31), and in 1905 it was announced that the three-year tests had been successful (40-1905:203).

In about 1910, the Division of Drainage Investigations entered into a cooperative agreement with the North Carolina Department of Agriculture and the North Carolina Experiment Station. The Federal and two State agencies furnished two engineers for studies of the prevention and control of erosion with special reference to terracing. The results of the continuing cooperative study were published in 1916 by the Station (20—236), the cooperation being shown by the personnel lists on the inside cover and by a footnote statement. In 1914, the Federal Division began a more extensive study of erosion control by field terracing and gully damming.

The transfer of all phases of agricultural engineering from the Office of Experiment Stations to the Office of Public Roads and Rural Engineering took effect on July 1, 1915. A general noncooperative compilation of erosion prevention through terracing was made by the new agency and published (28—512) in 1917. In the same year, in cooperation with the Missouri College of Agriculture, terrace systems were devised and their construction supervised as extension demonstrations on a few farms (50—1917:377).

In 1924, an experimental study of erosion on farm land was begun in cooperation with the North Carolina Agricultural Experiment Station, and continued for several years. It covered the rate of erosion as affected by the quantity and intensity of rainfall, soil types, ground slope, and kind of crop, on six plots differently cropped, and also included field and laboratory studies of terracing (50—1924).

NATIONAL COÖPERATIVE EROSION-CONTROL PROGRAM

This program, begun in 1929, was the natural outgrowth of some thirty-five years of increasing emphasis on the erosion problem. It was the direct result of the cooperative Forest Service—Weather Bureau forest-erosion experiments in Colorado, the Federal-State cooperative experiments in North Carolina, and the establishment by the Texas Experiment Station of extensive erosion and runoff studies at its Spur Substation in western Texas in 1926. Public attention finally was focused on the matter through a joint presentation of the erosion problem as a national menace, by the Bureau of Chemistry and Soils and the Forest Service (2; 32—33), in 1928.

The Congress, in 1928, made available the sum of \$10,000 for reconnaissance survey of eroding areas throughout the country in fiscal year 1929. The preliminary report showed eighteen separate agricultural areas or regions, characterized by different soil types and climatic conditions, in which destructive erosion was in progress and remedial measures were urgently needed. As a result, the appropriation bill for the fiscal year 1930 provided the Federal Department of Agriculture with \$160,000, part of it immediately available in the spring of 1929, to begin an effective attack on the joint problems of erosion prevention and water conservation.

The bill suggesting widespread collaboration, the Department of Agriculture immediately created a coöperation committee of five to develop a program of common research in the problem. The committee consisted of one representative each from the Bureau of Chemistry and Soils, the Forest Service, and the Division of Agricultural Engineering in the Bureau of Public Roads, and the directors of the New Jersey and Texas Agricultural Experiment Stations as representing the Association of Land-Grant Colleges and Universities. The committee met early in April, 1929, and rendered a first report on April 25. The program provided for the completion of the reconnaissance survey and for extensive field and laboratory research in every phase of the problem, including such engineering subjects as terraces, dams, drains, and tillage operations. To provide facilities for research, the committee further recommended the establishment of erosion experiment stations in the different eroding agricultural and forest areas, all to be co-operative with the State experiment stations and other agencies (25:252-69).

The Federal appropriations have been divided among three separate Bureaus. The first appropriation was \$160,000 for the fiscal year 1930, of which \$30,000 was allotted to the Forest Service, and \$65,000 apiece to the Bureau of Chemistry and Soils and the Division of Agricultural Engineering. For the fiscal year 1931, the total amount was increased to \$185,000, with an allotment of \$30,000 to the Forest Service and \$77,500 to each of the other units. For 1932 a further increase brought the total to \$330,000, of which \$100,000 went to the Forest Service and \$115,000 each to Chemistry and Soils and Agricultural Engineering, the latter being

made an independent Bureau at the beginning of the fiscal year. The soil-erosion item also was transferred from the appropriation for the Bureau of Chemistry and Soils to the miscellaneous items of the Secretary of Agriculture. As a result of the economy program, the \$230,000 allotted to Soils and Engineering was cut to \$200,000 and the other \$30,000 impounded as savings. For the fiscal year 1933 the total amount appropriated was \$289,160, of which \$89,160 was allotted to the Forest Service and \$100,000 each to the Bureaus of Chemistry and Soils and Agricultural Engineering. No deduction was made from these amounts.

The committee's plan for establishing an erosion experiment station in each of the eighteen eroding agricultural areas, and in several forest areas besides, has been followed as far as funds have been made available. In the agricultural areas, the stations are conducted jointly by the Bureaus of Chemistry and Soils and Agricultural Engineering, in coöperation with the respective State agricultural experiment stations. In the forest areas they are conducted by the Forest Service with the coöperation of the other two Bureaus named and with various State and county agencies. The land for these stations had been made available by the States, for the most part, or by commercial agencies within them.

In Agricultural Areas

An erosion experiment station near Guthrie, Oklahoma, was established in January, 1929, the land being provided by the Guthrie Chamber of Commerce. A second station was set up near Temple, Texas, in April, 1929. During the fiscal year 1930, four more were established; one on the Fort Hays Branch Station of the Kansas Agricultural Experiment Station, and the others near Tyler, Texas, Bethany, Missouri (33—82), and Statesville, North Carolina, the last named in coöperation with the State Department of Agriculture as well as with the Experiment Station. In fiscal year 1931, the seventh and eighth stations were established near Clarinda, Iowa, and Pullman, Washington (50—1929/1931). It was estimated that the total contributions of the States in rentals, purchases, laboratory facilities, etc., in connection with the first eight stations had totaled some \$84,000. In fiscal year 1932 two more stations were established, one near Zanesville, Ohio, and the other near La Crosse,

Wisconsin, thus bringing the total to ten (36—1931/1933). In the meantime, the erosion station established independently in 1926 by the Texas Agricultural Experiment Station on its Spur Substation had been brought into the national Federal-State coöperative program. The national economy program has prevented the establishing of stations since that time.

The following is a statement of the objects of the engineering research, as given by the Bureau itself (36—1933:8) :

The objects of the engineering investigations on the erosion-experiment farms are (1) to determine the water-carrying capacity of terraces for different soils and land slopes, and the required carrying capacity according to the fall, vertical spacing, and length of terraces; (2) to determine the effectiveness of terraces in preventing erosion and conserving moisture by comparing water run-off and soil losses on terraced and unterraced land; (3) to develop the most economical methods of constructing and maintaining terraces under different farming conditions and practices; (4) to determine the best available machinery for building terraces, and to design better machinery for the purpose; (5) to study the operation of various types of farm machines over terraced land, with a view to recommending changes in design to improve their operation; and (6) to improve the design and construction and to reduce the cost of various types of check and soil-saving dams for controlling erosion in gullies, terrace outlets, and road ditches.

In the collaborative research, the Bureau of Chemistry and Soils is responsible for the soils problems (29—316), and the Bureau of Agricultural Engineering for the engineering problems, the latter covering application of engineering principles to the problems of soil conservation. The Bureau is charged with research in terraces and dams through its Division of Structures, with study of terracing and tilling machinery through its Division of Mechanical Equipment, and with field-station research through its Division of Drainage and Erosion Control. The Division of Irrigation Investigations also works largely with the Forest Service on common problems of water conservation in connection with erosion prevention in forest areas. In 1931 the two Bureaus issued a coöperative popular bulletin (27—1669) on farm terracing.

It is interesting to note that, in about 1931, the Oklahoma Legislature enacted a law which permits counties and townships owning road-making machinery to loan the same to farmers without charge for the building of farm terraces (50—1931).

Recently, the Bureau of Chemistry and Soils has conducted a reconnaissance erosion survey of the watershed of the Brazos River in Texas, in coöperation with the Agricultural Experiment Station of that State. The results (34—186), published in 1934, show the coöperation prominently on cover and title pages.

In Forest Areas

The Bureau of Agricultural Engineering works with the Forest Service in extensive studies of erosion control and water conservation in the forested parts of the United States. Most of this coöperation is through the Bureau's Division of Irrigation and in coöperation with the similar agency of the States, both in the agricultural experiment station and the office of State engineer, in whatsoever department located. This work belongs properly to water conservation and flood control and will be treated fully in the chapter on Water Resources, in the companion volume on Natural Resources. So far as it is germane to agriculture it has already been discussed in the section on Soil Erosion and Protection in the chapter on Soils and Soil Management (pp. 231-254), where the State of California is used as an example of the relations developed in this field.

The publications listed in the Literature Cited at the end of this chapter which have been cited in this section on Soil-Erosion Engineering are Nos. 2, 20, 25, 26, 27, 28, 29, 32, 33, 34, 36, 40, 41, 42, and 50.

5. FARM-LAND EFFICIENCY ENGINEERING

UNDER THIS HEADING are included a few activities which do not come properly under the major technical divisions of this chapter, namely, irrigation, drainage, farm machinery and equipment, farm structures, and erosion engineering. The principal activity to be included is concerned with land-clearing operations, involving the removal of stumps, boulders, and similar debris in order to increase per-acre production and decrease per-acre costs of operation. Minor activities in farmstead planning are included also.

LAND CLEARING

Early Investigations and Relations

Investigation of methods of land clearing is comparatively recent. The earliest bulletin of any State agricultural experiment stations, and apparently the only one during the nineteenth century, was published by the State of Washington (55—28) in 1897. More than a decade later, the Washington Station resumed its investigations, partly in coöperation with the Office of Farm Management of the Federal Bureau of Plant Industry, and published a coöperative bulletin (55—101) in 1911, and two special bulletins (56—1 and 8) in 1910 and 1912 respectively. In the meantime, other States having large deforested areas took up similar studies. In the early years most of this work was done without coöperation. In later studies, official State units concerned with engineering, agricultural economics, and farm crops have worked together on these projects. Federal-State coöperation is noted below.

No agency of the Federal Department of Agriculture appears to have given attention to the problem of land clearing prior to 1908. The Office of Farm Management, established in the Bureau of Plant Industry in 1906, began preliminary studies in agricultural engineering, including some investigation of land-clearing matters, in 1908. An independent investigation of the costs of clearing logged-off land in the Pacific Northwest was published (48—25) in 1909. In the winter of 1909—10, the Office engaged with the Washington Agricultural Experiment Station in a joint study of methods of clearing logged-off lands, the results being published (55—101) in 1911 with the coöperative relation shown on the cover page.

At about the same time, similar studies were begun in coöperation with the Wisconsin Station and with the Minnesota Station through its Northeast Experiment Farm. A Wisconsin publication, appearing in 1911 and discussing the use of explosives in clearing land, showed the three-party coöperation on its cover and in a letter by the director (58—216). A Minnesota publication (17—134) issued in 1913 makes no other mention of the coöperation than the inclusion of a table (p. 24) containing data said in

the text to result from the three-party coöperation previously discussed. In 1914, the Office of Farm Management Investigations published an extensive discussion of machinery and methods for clearing land in the Lake States (28—91). No mention is made of the earlier coöperation with Minnesota and Wisconsin, but it seems probable that results of the investigations carried on jointly with those States are included in this more comprehensive bulletin.

On July 1, 1915, the Office of Farm Management was transferred from Plant Industry to independent status under the Office of the Secretary. In 1918, it published a farmers' bulletin (27—974) on land clearing which refers to the State bulletins cited above, and to others, but makes no mention of coöperation. No further studies in this field occurred.

Distribution of Surplus War Explosives

In 1920, the U. S. Department of Agriculture published (30—94) the results of a study, made by its Division of Agricultural Engineering and the U. S. Bureau of Mines, of the use of the War Department's surplus picric acid and TNT as blasting agents. Part of the field experiments were made jointly with the Wisconsin College of Agriculture (*op. cit.*, p. 4). A later publication on the use of explosives for blasting stumps (30—191) contained the results of experiments conducted by the Division of Rural Engineering of the Bureau of Public Roads, apparently without coöperation, but with mention of the earlier coöperation.

In 1921 there was begun a large-scale and long-continued coöperation in disposal of surplus war explosives for land-clearing purposes. Three primary objectives were involved, namely, to find an economical use for this otherwise wasted Government material, to enable farmers needing explosives to obtain them cheaply enough to make their use profitable, and to teach these farmers the best methods of doing the work. The intent was the removal of stumps from lands already in cultivation, rather than the bringing of entirely new areas under the plow.

In accordance with an act of Congress (Public No. 7, 66th Congress) some 12,000,000 pounds of picric acid were transferred from the Department of War to the Department of Agriculture for distribution to farmers to be used in land clearing. The distribu-

tion was handled by the Division of Agricultural Engineering of the Bureau of Public Roads, for the most part through the cooperative Federal-State Agricultural Extension Service. Farmers were charged for the expense of preparing and shipping and also one cent per pound to defray transportation charges and the expenses of the Federal and State agencies concerned. More than 7,000,000 pounds were thus distributed in 1922 and 1923, and vigorous extension campaigns were conducted by these agencies to induce farmers to increase the efficiency of their land through the removal of stumps. A resumé of the results obtained in the various States through this coöperative movement was published (50—1923:491-93) in 1923. The work was done chiefly in Minnesota, Michigan, Wisconsin, Idaho, and North Carolina, in this order.

The second explosive distributed under this coöperative plan was sodatol. In 1924, some 8,000,000 pounds of trinitrotoluol (TNT) and 10,000,000 pounds of sodium nitrate were on hand. Close research had developed a formula for an explosive made from these materials and later called sodatol. The distribution was completed in June, 1924, more than 14,000,000 pounds having been placed in Wisconsin, Washington, Minnesota, Michigan, Oregon, and North Carolina, in this order, and in many other States in smaller quantities. The distribution was handled under the same coöperative plan and with the same financial arrangements as for picric acid.

The third explosive distributed was pyratol, probably the best of the explosives for stumping. This was compounded from smokeless powder and sodium nitrate by a formula developed through earlier research. At the beginning of the fiscal year 1925, some 57,000,000 pounds of smokeless powder and 10,000,000 pounds of sodium nitrate were available. As in the case of sodatol, competitive bids for manufacturing the new explosive were obtained. More than 14,000,000 pounds were distributed coöperatively through the extension services during the year to all the States except California, Connecticut, and Pennsylvania, the principal States being those named in the previous paragraph. It was estimated that 95 per cent of the material was used in removing stumps and stones from cultivated fields. The charges to farmers were on the same basis as before, the overhead charge of one cent per pound

being divided equally between the Bureau of Public Roads and the State agency concerned. The final shipments of pyratol were made in April, 1928, some 8,000,000 pounds being distributed in that fiscal year.

From 1921 to 1928, more than 63,000,000 pounds of the three explosives were distributed to farmers who obtained them, under the terms already mentioned, at about one-third of their ordinary cost. Among the States coöperating, Minnesota, Wisconsin, and Washington used more than 10,000,000 pounds each, Michigan and Oregon more than 5,000,000 pounds each, and North Carolina, Idaho, and Iowa more than 1,500,000 each.

Recent Land-Clearing Studies

In 1927, the Division of Agricultural Engineering, in the Bureau of Public Roads, issued a new farmers' bulletin (27—1526) on clearing land of brush and stumps. It contained material from, or made reference to, various previous State and Federal publications, independent and coöperative. In 1929 the Division entered upon a general study of the problems of land clearing, mostly in collaboration with the agricultural experiment stations of the States concerned (36; 50).

One of the first phases of this study related to boulders and other stones. In 1929, the Division began studies in Minnesota, in common with the State, to determine whether stones are brought gradually to the surface of the ground by frost action. In the following year, joint study was begun in Pennsylvania to determine the efficiency of raising boulders to the surface by large plows and then blasting, the methods and costs of the various operations being determined. Thereafter, the joint experiments in land clearing included the removal of stones.

In 1929, a Federal study was begun in common with the Minnesota Agricultural Experiment Station to determine the costs of clearing land of brush and stumps by different methods, including burning, cutting, poisoning, plowing, and pulling. The work was conducted on four principal soil types in northern Minnesota, and by 1931 a report had been prepared on data obtained from 150 farms, showing man-hours, horse-hours, and cost of explosives for each operation. During the following year, similar studies were

made of the cost of clearing brush, stumps, and stones on 120 farms. During the same year a report was prepared on methods and costs of land clearing on different soil types in the Great Lakes States (50—1931:86).

In 1929, a special study of methods and costs of clearing land of trees and brush by use of poison was begun by the Federal Division in six central and eastern States, under different degrees of coöperation with State agencies.

FARMSTEAD PLANNING

The first coöperative activity in farmstead planning appears to have been in 1917, when a representative of the Division of Rural Engineering attended a farmers' short course at the Iowa Agricultural College and delivered a series of lectures on this subject (50—1917:379).

In 1919, the Office of Farm Management published on the laying out of fields for tractor plowing (27—1045). In 1920, the Division of Rural Engineering in the Bureau of Public Roads published general information on planning the farmstead (27—1132). In the same year, the Bureau of Plant Industry issued a similar publication on beautifying the farmstead (27—1087). Apparently, there was no coöperation in any of these.

In 1930, the Division of Agricultural Engineering of the Bureau of Public Roads began coöperative investigations of more efficient methods of farm-land development, mainly in collaboration with the agricultural experiment stations and other agencies. The studies covered the factors affecting the efficient use of machinery in farm operations, including size and shape of fields and the presence in them of gullies, meandering streams, wet spots, trees, timber, stumps, stones, etc. The scope of the studies was enlarged afterwards to include complete farm-management plans for a given farm, involving buildings and the use of livestock.

In 1930, these coöperative studies were begun in North Carolina to determine on typical farms the net benefit derived from the development of more efficient arrangement of farm fields. In 1931, coöperative projects were undertaken in Georgia and Minnesota, also, and in 1932 the work was extended to South Carolina and Virginia. One principal betterment was the doubling and trebling

of average size of fields. In that year, investigations were conducted on seventy-five farms in coöperation with the various State agricultural experiment stations. A development plan for each farm was worked out between a farm-management specialist and the farm owner. In 1933 the scope was increased to include eighty-five farms.

In 1930, coöperative assistance was given to the Federal Bureau of Agricultural Economics and the State of West Virginia on the agricultural engineering features of surveys made for the purpose of classifying land according to its utility.

The publications listed in the Literature Cited at the end of this chapter which have been cited in this section on Farm-Land Efficiency Engineering are Nos. 17, 27, 28, 30, 36, 48, 50, 55, 56, and 58.

6. FARM MACHINERY AND APPARATUS

UNDER THE GENERAL DESIGNATION of farm machinery and apparatus, there normally are included the very numerous implements designed for tillage, seeding and planting, harvesting, threshing or separating, hauling, cutting and grinding, and power development, as well as those used for specialized farm operations, such as spraying apparatus, dairy implements, scraping machinery, and repair tools.

EARLY ACTIVITIES

Several interesting and helpful articles on the development, manufacture, and use of farm machinery are to be found in the early annual reports of the U. S. Patent Office and the earlier annual reports of the U. S. Department of Agriculture (26). Similar papers appeared in the annual reports of certain State agricultural societies during the middle of the last century. No coöperation was developed during this period.

State Studies

The various State agricultural experiment stations published increasingly on studies of farm machinery and apparatus in the period following their organization in 1888. The volume of information was considerably larger than that on farm structures, with the single exception of silos. Publications on the following classes of implements had been issued by the States named before the end

of 1900: Plows and other tillage machinery—Minnesota, Missouri, Utah; harvesting machinery for hay or corn—Utah, Virginia; wagons (including tire width) and sleds—Missouri, South Carolina, Utah; haypresses—Mississippi; feed mills—Wisconsin; windmills—Nebraska, Wisconsin; dairy apparatus—Delaware, Illinois, Iowa, Maine, New York (Cornell), Pennsylvania, Vermont, Washington, Wisconsin; and spraying and fumigating equipment—Iowa, Mississippi, Missouri, New York (Geneva).

In the numerous investigations conducted by the State stations on farm machinery and apparatus there was frequent coöperation between the divisions of the station. Engineering phases were handled by the division of agricultural engineering, or its equivalent. Coöperation was commonly effected with the division of agronomy or farm crops in studies of tillage, seeding, harvesting, threshing, and power machinery. Minor coöperation developed with such divisions as animal industry, dairying, and horticulture, with reference to special machinery and apparatus for those industries. In recent years, large coöperation has developed between the agricultural engineering and the agricultural economics divisions.

As the economic aspects of agriculture became dominant after the turn of the century, the attention given by the stations to farm machinery and apparatus steadily increased. The establishment of courses in farm mechanics by the colleges of agriculture, and the growing heed to the problems of farm machinery on the part of the experiment stations, were largely responsible for the attention paid to agricultural engineering other than irrigation engineering by the U. S. Department of Agriculture from 1901 onward. In fact, it was the definite recommendations of the colleges of agriculture and the experiment stations through the appropriate committees of their Association which stimulated the Department into active interest.

Federal Activities

No attention to farm machinery and apparatus other than that required for irrigation operations was given by the U. S. Department of Agriculture until just after the opening of the present century. This is true in spite of the enormous importance of agricultural machinery in a country, once entirely agricultural, in which agriculture is still the largest single industry. This condition arose

in part from the fact that the production of agricultural implements was somewhat dependent on patent rights owned by private individuals or corporations, which was not true in relation to animal and plant organisms. It arose in part also because factories for the production of agricultural implements fairly kept pace with requirements of the agricultural industry, a condition less fully realized in the biological field during that period.

In the Office of Experiment Stations.—In 1901, the Secretary of Agriculture, and from 1902 until 1905 both the Secretary (26) and the Director of the Office of Experiment Stations (39), regularly recommended to the Congress that the Department begin to occupy the fields of agricultural engineering other than the one belonging to irrigation. Their action followed the recommendations made by the Committee on Rural Engineering of the Association of Agricultural Colleges and Experiment Stations, submitted to and approved by the Association in 1903. As a result, drainage investigations were authorized and begun in the fiscal year 1902. An appropriation of \$10,000 for the study of farm machinery was recommended by the Director and by the Secretary in 1903, as also a change in the name of the Division of Irrigation Investigations to make it include general agricultural engineering. The Office of Experiment Stations noted that the Wisconsin College of Agriculture already had received a State appropriation and established a Department of Farm Mechanics, with which the Federal Office had arranged a coöperative study of the application and use of power for agricultural purposes (39—1903:320).

In 1904, the Secretary of Agriculture noted that the annual purchase of farm machinery represented an investment of \$100,000,000, that much of this investment was lost through lack of knowledge of proper operation of the machinery, and that the manufacturers of farm machinery were asking for men trained to impart such knowledge. He estimated, therefore, that Departmental studies of farm implements would yield as valuable results as already had been obtained from irrigation and drainage studies. The Congress apparently made a small appropriation available, and in fiscal year 1905 an agent and expert in farm machinery and power was appointed by the Office of Experiment Stations. Coöperative experiments were started at the Iowa Station and at the

Federal irrigation station near Cheyenne, Wyoming, on the efficiency of windmills for the production of farm power.

In 1902, the Office of Experiment Stations published a bulletin on the evolution of reaping machines (41—103). The material, however, did not represent investigations made by the Office or in coöperation with it, but was a thesis written by a student of Ohio State University, and published by the Department in order to give the contained information a wider distribution. In 1905, the Office published a comprehensive paper by its newly appointed farm-machinery expert, on the evolution of farm-implement investigation. The discussion covered the extensive studies made by European countries, and the need of similar investigations in the United States of tillage, seeding, and harvesting machinery, and of the kinds of implements supplying motive power (40—1905:211—23). Independent investigations of corn-harvesting machinery made by the Iowa Station were published by the Federal Office (41—173), in 1906, and the continuing studies in that Station were made coöperative. In 1906, also, tests of alcohol as a fuel for the internal-combustion engines were made by the Office in coöperation with the Mechanical Engineering Department of Columbia University, and published by the Office under joint authorship (41—191).

For the fiscal years 1906 and 1907 no mention is made of agricultural engineering other than irrigation and drainage by either the Office of Experiment Stations or the Secretary of Agriculture. Apparently the Congress had not been favorable to appropriations for this purpose.

In the Bureau of Plant Industry.—The Bureau of Plant Industry had created an Office of Farm Management in 1906, and in 1908 this Office began certain studies of farm machinery and farm structures which were continued through the fiscal year 1913. These were not specific studies either of machinery or of buildings, but took account of the relations between both and the profitable operation of the farm (47—259:48—52). In general, they dealt with the character and cost of equipment on selected farms. Apparently there was little coöperation with the State stations.

As early as 1911, the Office of Farm Management conducted a study of farm equipment in Ohio (47—212), in coöperation with the Department of Coöperation of the Ohio Agricultural Experi-

ment Station, as shown by statements on the cover and in the text (pp. 3, 7, 8). While the authors were Federal men, help in obtaining or compiling the data was given by several Ohio Station men. Part of the data, covering minor articles of farm equipment, had been published already (48—44), in 1910, without mention of the coöperation.

Among the publications resulting from noncoöperative studies were one on traction plowing (47—170) in 1910, another on land clearing, including a considerable discussion of machinery (28—91), issued in 1914, and one on farm experience with tractors (28—174), issued in 1915. The fiscal years 1914 and 1915, however, reported no investigations under way. Apparently they were another transition period, like the years 1906 and 1907. On July 1, 1915, the sections of farm equipment and farm architecture were transferred from the Office of Farm Management to the Office of Public Roads and Rural Engineering.

RECENT OFFICIAL RELATIONS

As already noted in the Introduction to this chapter (pp. 843—846), many studies involving farm machinery and apparatus were conducted by various subject-matter Bureaus independently of the Division of Agricultural Engineering, especially in the years from 1916 to 1920, and some as late as 1922. In other cases, the Bureaus acknowledged the assistance of the Division in furnishing plans and specifications of apparatus and structures used and recommended by the Bureaus. Finally, the other units began to conduct their engineering studies in coöperation with the Division and to publish under joint authorship. Other coöperation developed between Federal and State agencies.

General Farm Equipment

The Division of Agricultural Engineering itself, in 1918 and 1919, prepared a series of farmers' bulletins on the care, repair, and operations of different classes of farm machinery (27—946, 947, 991, and 1036). One of these (27—991), covering the efficient operation of threshing machines, was the result of some collaboration between the Division, the Office of Farm Management (then an independent unit), and the Bureau of Plant Industry.

Statistics on the manufacture and sale of farm implements in

1920 were published (30—212) by the Division of Agricultural Engineering in 1922. The two authors previously had written much of the farm-machinery information published by the Office of Farm Management.

In May, 1925, the Secretary of Agriculture, at the request of the American Society of Agricultural Engineers and the National Association of Farm Equipment Manufacturers, appointed an Advisory Council on Research in Mechanical Farm Equipment. The council consisted of twenty-two members, of whom three represented the Division of Agricultural Engineering of the Bureau of Public Roads, one represented the Office of Experiment Stations, and nine each represented the two organizations making the original request. The nine members representing the American Society of Agricultural Engineers were all from the engineering staffs of the agricultural colleges and experiment stations.

During 1926 and 1927, a nation-wide survey of research in mechanical farm equipment was made under the auspices of the Advisory Council. In 1926 the director of the survey was J. B. Davidson, head of the Agricultural Engineering Division of the Iowa Experiment Station, who was given leave of absence for nine months under an appointment from the Division of Agricultural Engineering of the Federal Bureau of Public Roads. In December of that year, the Department issued his preliminary report (7) which contained a statement of the history and object of the survey, a list of more than four hundred suggested research problems in this field, and a report of the research program in progress in 1926. The latter was prepared by a representative of the Office of Experiment Stations.

During 1927 and the early part of 1928, the survey was under the direction of H. B. Walker, then head of the Division of Agricultural Engineering in the Kansas Agricultural Experiment Station, and a comprehensive final report was published (34—38; 53) in December, 1928. The report suggested (p. 3) a considerably enlarged program of research in the field of mechanical farm equipment to be conducted by the State agricultural experiment stations and the Bureau of Agricultural Engineering of the U. S. Department of Agriculture, with adequate supervision and coördination of the projects by the Office of Experiment Stations.

Cotton Production and Ginning Studies

From about 1917 onward, Federal agronomists working with cotton had been endeavoring to develop a press-wheel attachment for cotton planters which would place the seed at a uniform depth in the soil. Apparently there was no coöperation with the agricultural engineers during the early years of this endeavor. In 1926, a Federal *Department Circular* was published (30—381) by the Bureau of Plant Industry, in which it was stated that the actual specifications for the improved attachments had been prepared in coöperation with the Division of Agricultural Engineering of the Bureau of Public Roads.

In 1928, the Division coöperated with the Texas Agricultural Experiment Station in a study, made in northwestern Texas, of equipment and methods of harvesting cotton other than by hand. The implements tested included strippers and pickers, and machinery for cleaning stripped cotton. The results of the study were published by the Texas Station (24—452) in 1932.

In 1931, the Division established a series of projects on the mechanics of cotton production in coöperation with the Alabama and Mississippi Agricultural Experiment Stations. The coöperation is still in effect. The projects include machine practices in seed-bed preparation, seeding, cultivation, and weed killing, use of labor-saving machinery, efficiency of field machinery, control of large machine units on hillsides, and tests of a mechanical cotton picker. A dynamometer was developed for testing the draft of small farm implements, and power requirements of such implements was determined on different soil types. Attachments for placing the cotton seed at different depths in the soil were devised in 1932, and good crop yields resulted from their use in 1933.

In 1930, the Division of Agricultural Engineering began a comprehensive series of experiments on cotton harvesting, drying, and ginning, in coöperation with the Federal Bureau of Agricultural Economics and the Delta Branch Station of the Mississippi Agricultural Experiment Station at Stoneville, Mississippi. This work was an expansion of the previous studies of the Bureau of Agricultural Economics on factors affecting the quality of cotton fiber. The studies included harvesting at four distinct periods, con-

ditioning the seed cotton in different ways before ginning, and the use of different ginning methods and machinery. In 1931, a special ginning laboratory was built at the Delta Branch Station, with special funds appropriated by Congress for that purpose. In the succeeding years, more than six thousand samples from several different States were ginned annually. The tests included the use of cleaning machinery for sled-harvested and machine-stripped cotton, the use of both roller and saw gins with the saw and rolls operating at various speeds, and studies of the moisture content. The development of apparatus for drying seed cotton before ginning is discussed later along with other miscellaneous implements and apparatus.

In 1933, preliminary studies were begun of the use of roller gins on Pima cotton in the Salt River Valley of Arizona, in coöperation with the Federal Bureaus of Agricultural Economics and Plant Industry. In the meantime, an important series of tests of the engineering features of cotton ginning was begun in coöperation with the principal manufacturers of cotton gins at their test plants in Alabama and Georgia, using both short-staple and long-staple cotton under different conditions. These experiments were conducted in coöperation with the Division of Cotton Marketing in the U. S. Bureau of Agricultural Economics (29—396), and followed previous extensive independent investigations by that Division (27—1465).

The Federal Bureau of Chemistry, through several years, made investigations of the cause and prevention of the numerous fires occurring in cotton gins. The publications containing the results appeared at intervals (30—28 and 271; 32—76) and indicated that the inquiry was conducted independently of other official agencies.

Corn and Grain-Sorghum Machinery

These two crops are combined for purposes of discussion because they are similar in size and habit, and also are sown and cultivated by the same machinery.

Corn-production machinery.—The first attention given to mechanical equipment used in production of corn was the publication by the Office of Experiment Stations in 1906 of the results of independent investigations of corn-harvesting machinery made by

the Iowa Experiment Station (41—173). Continuing studies were made coöperative, but farm-machinery investigations by the Office of Experiment Stations were discontinued about that time. In 1918 the Office of Farm Management published an apparently independent study of the use of machinery in cutting corn (27—992).

In 1928, the Department of Agriculture brought out a *Farmers' Bulletin* on the use of the husker-shredder in the eastern part of the corn belt (27—1589). This bulletin, jointly authored by the three agencies, contains the results of a study conducted in common by the Division of Farm Management and Costs in the Bureau of Agricultural Economics, the Section of Mechanical Farm Equipment in the Division of Agricultural Engineering of the Bureau of Public Roads, and the Division of Animal Husbandry in the Bureau of Animal Industry.

In 1931, the Division of Mechanical Equipment in the Bureau of Agricultural Engineering began coöperative experiments with the Iowa Experiment Station in a study of the power, machinery, and labor requirements of corn production, under typical corn-belt conditions. A tractor was altered and equipped with a dynamometer to determine power delivered to drive wheels, drawbar, and power take-off simultaneously. Tests of the efficiency of numerous commercial picker-huskers were conducted, and the manufacturers informed of the operating results of their own machines in order that desirable improvements might be made. Experiments with corn pickers have been continued, and one of a new design was built in 1933. Labor and power requirements have been determined for drilled, checked, and listed corn. Other experimental equipment constructed in these investigations includes a one-man wagon hitch, a rotary-weeder attachment for a disk harrow, and a check-wire crossover for the four-row tractor-drawn corn planter. In connection with studies of the relation of tillage machinery to soil erosion, there were designed and constructed three implements, a lister attachment to make dams in the furrows at short intervals, a planter depositing the kernels in small depressions, and a cultivator leaving depressions between the rows in order to conserve rainfall and prevent erosion.

Numerous coöperative engineering studies have resulted from

the invasion of American corn fields by the European corn borer. These have included the modification of existing machinery, and the designing and construction of new types for specific purposes. The work is discussed later in this chapter along with other engineering investigations in the control of insect pests.

Grain-sorghum harvesting.—In 1926, the U. S. Department of Agriculture and the Kansas and Oklahoma Agricultural Experiment Stations coöperated in a study of methods in harvesting grain sorghum. The increased use of the combined harvester-thresher for harvesting wheat in the Great Plains led to the investigation of its possible use on grain sorghums. The official Federal units taking part in the study were the Division of Cereal Crops and Diseases, in the Bureau of Plant Industry, the Grain Division and the Division of Farm Management and Costs in the Bureau of Agricultural Economics, and the Division of Agricultural Engineering in the Bureau of Public Roads. The Departments of Agricultural Engineering, Agricultural Economics, and Agronomy of the Kansas and Oklahoma Stations, and the Engineering Experiment Station of the Kansas Agricultural College were the State collaborators. In the resulting comprehensive Federal publication (29—121) the coöperation is shown on the title page and in the text (pp. 1–2). The bulletin was prepared by the four Federal Divisions, with the names of assisting State men shown in a footnote. A popular discussion (27—1577), showing the coöperation of all these agencies, was published in 1928.

Grain-Production Machinery

The first instance of Federal-State relations in connection with machinery used in producing small grains was the publication by the Office of Experiment Stations in 1902 of a bulletin (41—103) on the evolution of reaping machines. This was a contribution from Ohio State University, but published by the Department in order to give wide distribution to the information contained.

In the very dry season of 1914, many disastrous grain-separator fires occurred in the Pacific Northwest. In 1915, the Bureau of Chemistry and the Division of Rural Engineering in the Office of Public Roads and Rural Engineering coöperated in investigations of the cause and prevention of such fires. The University of Idaho

provided offices, laboratories, and electrical apparatus, together with some assistance from staffs. Frequent conferences were held with the staff members of the Washington Agricultural Experiment Station. The results were published (28—379) in 1916, under the joint authorship and as a joint contribution of the two Bureaus. The studies covered the use of blower fans, sprinkling devices, and the grounding of the separators to remove accumulating static electricity.

During the seasons of 1917, 1918, and 1919, three Federal Bureaus, Chemistry, Markets, and Plant Industry, coöperated on the further improvement and installation of dust-collecting fans in grain separators. The results were published (30—98) in 1920. In 1918, the Office of Farm Management issued a Federal bulletin on the efficient operation of threshing machines (27—991) in which it acknowledged assistance from the Bureau of Plant Industry and the Division of Agricultural Engineering.

The rapid introduction of the combined harvester-thresher, popularly called the "combine," into the humid eastern States after the World War, created numerous new engineering and grain-handling problems.

In the harvest season of 1926, a coöperative investigation of the problem of harvesting small grains with this machine was conducted in the Great Plains. The U. S. Department of Agriculture was represented by the Division of Farm Management and Costs in the Bureau of Agricultural Economics, the Division of Cereal Crops and Diseases in the Bureau of Plant Industry, and the Division of Agricultural Engineering in the Bureau of Public Roads. The Agricultural Experiment Stations of Texas, Oklahoma, Kansas, Nebraska, and Montana coöperated in the field studies, each within the borders of its own State. The comprehensive publication containing the results (29—70) was issued in 1928 under Federal authorship, and showed the coöperation prominently on the cover and again in the text. The study was continued in 1927 in coöperation with the experiment stations of Illinois, Indiana, Pennsylvania, South Dakota, and Virginia. A popular presentation of the results of the two-year investigation was published (27—1565).

During the grain-harvest season in 1928, a far-reaching co-operative study of these problems was made in Minnesota. The

agencies involved were the U. S. Department of Agriculture, the Minnesota Agricultural Experiment Station, and three of its substations. The comprehensive publication containing the results (17—256), issued in 1929, had seven authors, four representing Minnesota and three the Federal Department. It is interesting to note that the Minnesota Station was represented by four Divisions, namely, Agricultural Engineering, Farm Management and Agricultural Economics, Agronomy and Plant Genetics, and Agricultural Biochemistry. The Department of Agriculture was represented by the Grain Division, and the Division of Farm Management and Costs of the Bureau of Agricultural Economics, and the Division of Agricultural Engineering in the Bureau of Public Roads. The coöperation was plainly shown in a cover statement and by the scientific titles of the numerous authors.

In 1928, a study similar to the above was made in Illinois and Indiana, and included the harvesting not only of small grains but also of soybeans and clover with both combines and binders. The same Divisions of the three Bureaus of the Federal Department of Agriculture and the Agricultural Experiment Stations of Illinois and Indiana took part. The resulting publication (29—244) was put out by the Department in 1931 under the authorship of the three Divisions named, the coöperation being shown on a box on the cover, in a statement of coöperation and personnel on the inside of the front cover, and the station coöperation on the title page.

A popular discussion of the operation and care of the combined harvester-thresher, based on the coöperation of the Federal agencies with all of the States mentioned above and with North Dakota in addition, was issued (27—1608) in 1929.

In 1930, the Office of Cereal Crops and Diseases of the Bureau of Plant Industry and the Montana Agricultural Experiment Station coöperated in a study of flaxseed production by power-farming methods in the northern section of the Great Plains, and the results were published under joint authorship (27—1650) by the Federal agency.

Sugar-Beet Machinery

The Division of Agricultural Engineering of the Bureau of Public Roads began studies of machinery and labor requirements for

sugar beets in 1929. By 1931, three types of beet harvesters were being investigated under field conditions in California and Colorado. A blocking machine was developed and tested in coöperation with the California and Colorado Experiment Stations. In 1932 and 1933, the collaboration was continued with the two States, and the major portion of the investigation brought in also the Federal Bureaus of Plant Industry and Chemistry and Soils. The scope of the experiments included tests of different types of beet planters, including a four-row planter tested also in Nebraska and North Dakota on different soils, as well as crust-breaking implements, harvesting machinery, and apparatus for distributing fertilizers. Another important investigation was in the thinning of beets by arsenic spray in California, and with the blocking machine in California and Colorado. The latter was adopted for commercial use, and the results of the tests upon it were published by the Department (33—97). This leaflet was prepared jointly by the Division of Mechanical Equipment (Bureau of Agricultural Engineering) and the Division of Sugar-Plant Investigations (Bureau of Plant Industry), with the coöperation of the California and Colorado Stations and of commercial sugar companies in various States shown in the footnote.

Fertilizer Distributors

The use of the new concentrated fertilizers, developed by the Fixed Nitrogen Laboratory in coöperation with other Federal agencies, introduced new problems in the mechanical application and placement of smaller quantities of material. On July 1, 1924, the Division of Agricultural Engineering in the Bureau of Public Roads began coöperation with the Divisions of Fixed Nitrogen Investigation and Soil Fertility, now included in the Bureau of Chemistry and Soils. At first, a study of the mechanical problems involved was conducted in laboratory and field at the Arlington Experiment Farm in coöperation with the other Federal Bureaus. Thereafter, experiments were made with different crops in various States in more or less coöperation with the State Agricultural Experiment Stations and the two Divisions of the Bureau of Chemistry and Soils. In 1930, a discussion of the factors affecting the mechanical application of fertilizer to the soil was published (29—

182). It had the joint authorship of the Division of Fertilizer and Fixed Nitrogen Investigations in the Bureau of Chemistry and Soils and the Division of Agricultural Engineering in the Bureau of Public Roads. The material was based in part on the replies to a questionnaire concerning fertilizer practices which had been sent to each interested State experiment station.

In about 1929, a Joint Committee on Fertilizer Application was created by the American Society of Agronomy, the American Society of Agricultural Engineers, the National Association of Farm Equipment Manufacturers, and the National Fertilizer Association. In 1929, the study of mechanical placement of fertilizers was begun on a large scale in South Carolina by the Division of Agricultural Engineering, in coöperation with the Bureau of Chemistry and Soils, the South Carolina Station and its substations, and the Joint Committee. In that year, field tests were made on twenty-four different distributing machines. The results obtained in 1929 were published (6) in a private engineering journal. The studies in South Carolina were conducted under an advisory committee consisting of representatives from the Federal Divisions of Agricultural Engineering, Fixed Nitrogen Investigations, and Soil Investigations, the South Carolina Experiment Station, and the National Fertilizer Association. Funds for conducting the research were contributed by the National Association of Farm Equipment Manufacturers, the National Fertilizer Association, the Superphosphate Institute, and several commercial fertilizer companies. A progress report on the results obtained in South Carolina in 1930 was published by the Federal Department (32—192), and a similar report was issued (32—264) on the results obtained in 1931.

In the meantime, the coöperative experiments had been expanded to include other States and other crops. In 1931 and 1932, studies were begun of the effects of different placement methods of potato fertilizers, in coöperation with the Agricultural Experiment Stations of Michigan, New Jersey, and Ohio. In 1931, also, similar studies concerning cotton were begun in Arkansas, Georgia, Mississippi, Louisiana, North Carolina, Oklahoma, and Texas, and studies concerning canning crops at the New York (Geneva) Station. By 1932, the investigation of the mechanical application of fertilizer had included cotton in eight States, potatoes in five

States, sugar beets in four States, beans in two States, and corn in one State. In 1933, the experiments were extended to cover applications to tobacco in four States. Ten different experimental machines were in use. Special equipment had been designed and constructed, including four entirely new machines and additions to others (36).

Insect-Control Machinery

The principal studies of mechanical appliances for the control of insect pests have related to dusting and spraying apparatus, primarily for boll-weevil control; tillage and harvesting machinery for the destruction of such pests as the corn borer, pink bollworm, and Japanese beetle; and miscellaneous apparatus for the control of these and other insects. Coöperation with the Division of Rural Engineering was begun by the Bureau of Entomology as early as 1918. Coöperation of other Bureaus with the engineers developed at a later date. This probably was in part because the entomologists had less training and experience in farm mechanics than the agronomists, and in part because the spread of the boll weevil made the problem more acute at an earlier date.

Dusting and spraying equipment, including airplanes.—In 1918, the Federal Bureau of Entomology enlisted the coöperation of the Division of Rural Engineering in the Bureau of Public Roads in the designing of dusting apparatus for use on cotton to prevent boll-weevil injury. The design was completed in 1919 and public patents applied for. A full discussion of boll-weevil poisoning was published (28—875) by the Bureau of Entomology in 1920. The coöperation of the Division of Rural Engineering was shown by a footnote to the discussion of dusting machinery (pp. 18–26). In 1920, the engineers published on dusting machinery for boll-weevil control (27—1098) in coöperation with the Bureau of Entomology. Patents were granted on the apparatus, and commercial production was promoted. An engineer was detailed to assist the Bureau of Entomology in developing apparatus (50—1921:42). An engine-driven tractor-duster was developed in 1924.

In 1922, the problem of equipping airplanes with dusting machinery arose for the first time (50—1922:502). The Air Service of the U. S. Department of War joined with the Bureaus of Ento-



mology and Public Roads of the U. S. Department of Agriculture in dusting experiments with airplanes in Louisiana in 1922. The results were published (27—1319) in 1923, under joint authorship of the agricultural agencies. The Air Service furnished two dusting planes and one photographing plane, together with the necessary personnel. This coöperation grew out of experiments conducted in the previous year by the Ohio Experiment Station and the Army Air Service in dusting catalpa plantations (19). In 1923, a new type of dusting apparatus was designed for use on airplanes, and a public patent secured. In the same year, a study was begun of types of airplanes suitable for dusting operations. In 1924, the three Federal agencies, including the Air Service, published a bulletin (28—1204) under joint authorship, on dusting cotton from airplanes.

The tests begun in 1922 on airplane dusting of cotton had a very interesting corollary. This work was done at the Delta Laboratory of the Division of Cotton Insects, Bureau of Entomology, located at Tallulah, Louisiana. Not far away was a laboratory of the Division of Insects Affecting Man and Animals. As a result of the work on cotton, the three Federal agencies in 1923 and 1924 conducted similar tests on dusting swamp waters and adjacent swamp vegetation for the control of malaria mosquitoes. The Bureau of Entomology published the results (30—367) in 1926, showing by footnote and text (pp. 13—14) the coöperation of the engineers and of the Army Air Service.

From 1924 to 1928, the development of apparatus for airplane dusting of cotton against the boll weevil was continued by the two Bureaus, and effective apparatus designed and constructed. Two publications (33—37; 35—1928:117—20) containing some of these later results appeared in 1929. Balloons also were tested for this purpose. The study of airplanes finally included the development of flying methods for effective dusting. In 1932, the coöperative experiments on dusting machinery at the Delta Laboratory in Louisiana were discontinued, and a final publication was prepared.

In 1927, the Division of Cereal and Forage Insects and the Division of Sugar-Plant Investigations, of the Bureaus of Entomology and Plant Industry, respectively, carried out coöperative experiments in the application of sodium fluosilicate by airplane in at-

tempts to control the sugar-cane moth borer. The results were published in 1928 under joint authorship (32—45).

In 1928, the Division of Deciduous Fruit Insects, Bureau of Entomology, and the Division of Agricultural Engineering of the Bureau of Public Roads coöperated in comparative tests of dusting by means of commercial airplanes and of a ground machine for the control of the blueberry maggot. The engineers surveyed and marked the areas for plane dusting. The results were published (32—123) in 1930, and the coöperation mentioned in a footnote.

In 1932, a study of spraying and equipment and methods for use against the insect pests and fungus diseases of pecans was begun in Georgia as a coöperative enterprise of the Bureaus of Entomology and Plant Industry. The work was confined primarily to the mechanical features of nozzles and spray guns. In 1933, improvements were made in commercial spraying apparatus to adapt it for spraying corn in the field as protection against corn borers.

The Bureau of Entomology and the Division of Agricultural Engineering of the Bureau of Public Roads in the Federal Department of Agriculture have coöperated extensively on the preparation of lime-sulphur concentrate for spraying fruit trees and on designs of plants for its manufacture. In 1922, they issued under joint authorship a bulletin (27—1285) chiefly devoted to description and detailed construction of such plants.

Machinery and implements for corn-borer control.—A comprehensive publication on the results of the first ten years, 1917—26, of investigation into the control of the European corn borer was published (29—53) by the Bureau of Entomology in 1927. It records the results of studies of control by machinery in coöperation with the Divisions of Agricultural Engineering in the Michigan and Ohio Experiment Stations. These studies included the effects of the use of shredders and a combined harvester, husker, and silage cutter, as well as numerous experiments with plowing under of infested stalks.

In fiscal year 1928, the Federal Department of Agriculture, State departments of agriculture, and State agricultural experiment stations began a very comprehensive program for control of the European corn borer, which for ten years had been gradually spreading southward and westward into the corn-growing sections

of the United States. The chief Federal agencies concerned were the Bureaus of Entomology, Plant Industry, and Public Roads, and later the Plant Quarantine and Control Administration, all of the Department of Agriculture. These units coöperated widely and closely with each other and with the State agencies concerned, including the Federal-State Agricultural Extension Service. The engineering problems were handled by the Division of Agricultural Engineering of the Bureau of Public Roads in coöperation with the other Federal units named, and with the Experiment Stations, especially those of Illinois, Ohio, Pennsylvania, and the New England States. Several special corn-borer experiment farms were established as the work progressed, and on these many of the experiments and public demonstrations with machinery were conducted. In 1930, a farm at Berkley, Massachusetts, acquired by the Plant Quarantine and Control Administration, was run coöperatively by the unit and the Bureaus of Entomology and Public Roads. In 1931, headquarters for coöperation with the New England stations were established at South Norwalk, Connecticut. In the same year, a large experiment farm was acquired near Toledo, Ohio, for operation jointly with the Bureau of Entomology. In 1933, the eastern headquarters were moved to Trenton, New Jersey.

Coöperative studies on machinery as an aid to corn-borer control were of a wide range, covering tillage implements, harvesting machinery, stalk-gathering devices, stalk-splitting implements, burning apparatus, and miscellaneous devices. In 1929 alone, more than sixty kinds of apparatus were tested. Tillage implements included plows of various width; numerous attachments for burying stalks, such as floating coulters, jointers, and trash guides; a device for measuring the depth and width of plowing; and dynamometer studies of the draft of plows in different soils. Harvesting machinery included a low-cutting hand hoe which became commercial, low-cutting attachments for corn binders, several different sled-type stalk shavers, husker shredders, a combined silage cutter and harvester, and a picker with crushing rolls. Finally, a survey of harvesting methods was conducted with the coöperation of the Illinois Station.

The problem of assembling infested stalks in the fields after harvest caused attention to the development of poling and raking

implements (including a side-delivery rake), to stalk loaders, and to stalk-baling processes and pressures. Splitting infested corn stubble in the fields was attempted with various stubble pulverizers, stalk-choppers, and a stubble-slitter attachment for the corn binder. The problem of burning stalks in the field led to the development of different types of burners, auxiliary apparatus for use in windy weather, and a high-pressure hose for supplying fuel oil. Under miscellaneous apparatus may be placed the development of commercial spraying equipment for use on growing corn.

Numerous publications have recorded the extensive coöperation in corn-borer control by machinery. The results of such work (29—53) by the Bureau of Entomology in coöperation with the Michigan and Ohio Stations in the ten years from 1917 to 1926 have been noted above. The year 1930 saw published (32—132) a full discussion of fighting the corn borer with machinery in the two-generation area. This resulted from coöperation of three Federal agencies, the Bureau of Entomology, the Division of Agricultural Engineering of the Bureau of Public Roads, and the Plant Quarantine and Control Administration (now Bureau of Plant Quarantine), with the Division of Agricultural Engineering of the Ohio Station, and the Ohio Agricultural Extension Service. Similar studies by the agricultural engineers in the western, one-generation area were published (32—321) in 1934, with no mention of any coöperation. Tillage studies for corn-borer control led to the issuing of two publications besides those just mentioned. Plowing as a control measure in western New York was discussed by the Bureau of Entomology and the Plant Quarantine and Control Administration (32—165) in 1931. In the next year, plowing with mold-board plows was discussed by the Bureau of Entomology, with acknowledgment of the coöperation of the Plant Quarantine and Control Administration, the Bureau of Agricultural Engineering, and State experiment stations (27—1690).

Publications on harvesting machinery include low-cutting harvesters, sled-type stalk shavers, and husker-shredders. In 1929, the Division of Agricultural Engineering published on low-cutting devices for harvesting corn (34—56), in coöperation with the Bureau of Entomology and State agencies. In 1930 and again in 1932, the Division of Mechanical Equipment of the Bureau of

Agricultural Engineering published on the construction of the sled-type corn shaver (34—69 and 142). The coöperation of farmers, county agricultural agents, and engineers of the experiment stations is acknowledged, and reference made also to *Leaflets No. 14* and *No. 17* of the Ohio Agricultural Extension Service. Two publications (27—1589 and 1662) have been issued on husker-shredders. The first in 1928 was a joint contribution from the Federal Bureaus of Agricultural Economics, Agricultural Engineering, and Animal Industry, with the coöperation of the Illinois, Indiana, Michigan, and Ohio Experiment Stations. The study was made in the corn belt not yet infested by the corn borer, but was of value in showing probable effects of the use of such machinery on the borers when present. The second, issued in 1931 by the Federal Division of Agricultural Engineering, discussed husker-shredders in corn-borer control, but made no mention of the coöperating agencies.

Machinery for control of miscellaneous insects.—Alfalfa aphids: From 1926 until 1931, large-scale coöperative experiments were conducted in the Antelope Valley of California on spring burning of alfalfa fields for the control of aphids. The studies were made by the Bureau of Entomology and the Division of Agricultural Engineering of the Bureau of Public Roads, U. S. Department of Agriculture, in coöperation with the Engineering and Agronomic Divisions of the California Experiment Station and the Agricultural Extension Service of Los Angeles County. The results of the experiments were published (32—287) in 1933 under joint authorship of the two Federal agencies and the California Station. A later publication (32—307), under entomological authorship, also acknowledges the coöperation of the other agencies.

Grasshoppers: These insects have been an agricultural pest for many decades, but have not been considered an engineering problem. In 1932 a limited study was made of the use of farm machinery in controlling them in the spring-wheat area. An end-gate seeder was modified to permit the distribution of poison bran at any desired rate. Experiments were conducted also with a lime-sower for the same purpose.

Japanese beetles: In 1933, the Bureau of Agricultural Engineering coöperated with the Bureau of Entomology in field tests

of various types of rotary plows and rototillers in destroying the larvae of this insect.

Pink bollworms: Since 1930, the Federal Bureaus of Agricultural Engineering and Entomology have been coöperating in a study of machinery and apparatus for destroying the pink bollworm in cotton. These have included tests in Louisiana and Mexico of a feed grinder for destroying the worms in cotton seed at the gin. Experimenting to control the insect through plowing has been done at Presidio, Texas, in coöperation with the Texas Station, and also in the Salt River Valley of Arizona. Other studies cover machinery and apparatus for cutting, raking, and burning the infested stalks, likewise in coöperation with the Texas Station.

Tractors, Trucks, and Other Power Equipment

One of the most significant recent changes in American agriculture has been the shift from animal to mechanical power. Already it has reduced the horse and mule population from about 25,000,000 to about 18,000,000 and thereby it has released some 35,000,000 acres of land once used in growing feed for 7,000,000 animals. This release in turn, has been one factor in creating the present problem of crop surpluses.

Alcohol-gasoline fuel tests.—The question whether alcohol or other fuel can be substituted for gasoline in automotive equipment has arisen from time to time. In 1906, for instance, the Federal Office of Experiment Stations, in coöperation with the Mechanical Engineering Department of Columbia University, tested alcohol as fuel for internal-combustion engines, and published the results under joint authorship (41—191). In 1933, again, the possibility of alcohol-gasoline blends in automotive engines was agitated. The Bureau of Agricultural Engineering conducted both field and laboratory tests on tractors and trucks, comparing various blends with straight gasoline. Road tests were made with trucks, and plowing and belt tests were made with tractors. Field studies were conducted at the coöperative corn-borer station in Ohio, and laboratory tests at the Engineering Experiment Station of the United States Naval Academy at Annapolis. Blends up to 30 per cent alcohol were found effective.

Tractor studies.—In 1917, the Division of Rural Engineering

in the then Office of Public Roads and Rural Engineering, made preliminary arrangements for an investigation of the economic and engineering phases of the use and standardization of tractors in coöperation with the Office of Farm Management (50—1917: 380). This latter unit was then an independent office under the Secretary, but later became a unit of the Bureau of Agricultural Economics. The Office of Farm Management, however, apparently continued a series of independent studies of the economics of tractor use, and published them in popular form (27—963, 1004, 1013, 1035, and 1093) between 1918 and 1920.

In 1920, a Farm Power Conference was held in Chicago. Soon thereafter, the Secretary of Agriculture appointed a Departmental Committee on Farm Power, consisting of the chiefs of the Bureaus of Animal Industry and Public Roads, and the Office of Farm Management and Farm Economics. After the creation of the Bureau of Agricultural Economics in 1922, the chief of that Bureau replaced the chief of the Office of Farm Management on this Committee.

Following the creation of the Federal Committee on Farm Power, a series of coöperative investigations was begun by the Division of Agricultural Engineering of the Bureau of Public Roads, the Division of Animal Husbandry of the Bureau of Animal Industry, and the Division of Farm Management and Costs of the Bureau of Agricultural Economics, the latter succeeding the independent Office of Farm Management and Farm Economics. The first coöperative study covered the cost and utilization of power on 286 farms where tractors were owned in Illinois, Indiana, and Ohio. Some assistance was received from the Experiment Stations of these States. The comprehensive publication containing the results (28—997) was issued in 1921 as a joint contribution of the three Federal agencies, coöperation being shown by a box statement on and inside the cover and by a text footnote.

In 1921, the three Federal agencies coöperated with the Kansas and Nebraska Colleges of Agriculture in a study of the use of tractors and horses in the winter-wheat belt of Oklahoma, Kansas, and Nebraska. The resulting publication (28—1202), issued in 1924, was authored jointly by the Federal Divisions of Farm Management and Farm Engineering, with acknowledgment of the co-

operation of the other Federal and State agencies (p. 89). A third bulletin discussed the utilization and the cost of using tractor-drawn implements.

In the meantime, the more popular results of these coöperative studies of tractors and horses in the corn belt were issued as a series of six *Farmers' Bulletins* (27—1295 to 1300) in 1922. All have a full-page statement by the Committee on Farm Power in a box on the inside of the front cover, and a statement on the rear cover that they were joint contributions of the three Bureaus concerned. Five were jointly authored by Agricultural Economics and Agricultural Engineering, and one (27—1298) on the cost of using horses on corn-belt farms was authored jointly by Agricultural Economics and Animal Industry.

A seventh popular bulletin (27—1278), published in 1922, discussed tractors on southern farms. It was one of the series of studies projected by the Office of Farm Management, but by this date the two men who had conducted the studies for that agency had been transferred temporarily to the staff of the Division of Farm Engineering in the Bureau of Public Roads, and the publication was issued from that Bureau. There had been coöperation with the Bureau of Crop Estimates in obtaining the names of farmers through its township correspondents.

During 1924 and 1925, the Division of Agricultural Engineering of the Federal Bureau of Public Roads coöperated with the Agricultural Engineering Division at the California Experiment Station in a study of tractor farming in California. Need for the study arose from the fact that the dust resulting from fine and gritty soils and long dry summers causes excessive wear on tractor parts. Information was obtained through questionnaires mailed in 1924 to all known tractor owners in the State, and from direct contact with owners at College of Agriculture short courses and through other extension activities. The results were published by the Station (3—415) in 1926, under Federal-State authorship.

In coöperation with the Office of Farm Management and Costs in the Bureau of Agricultural Economics, a study was made of the proper arrangement of farm fields for tractor plowing, and a revised edition of an earlier independent publication was prepared (27—1045).

Beginning in 1931, the Bureau of Agricultural Engineering co-operated with the manufacturers of tractor equipment in studies to determine how such equipment could be made sufficiently flexible to operate over terraces, which by that time were becoming common structures on farms in many parts of the United States.

Intrastate tractor studies in Nebraska: A rather unusual relationship has existed in Nebraska for the past fifteen years. A law was passed by the Nebraska Legislature, effective June 15, 1919, that forbade the sale of tractors in that State except under permit issued by the State Railway Commission, after satisfactory tests had been made. The law further provided that the tests should be conducted by three engineers of the State University, who should submit their findings to the Railway Commission. Accumulated results of these tests are found in ten bulletins of the Nebraska Station issued between 1921 and 1932 (18—177, 200, 212, 220, 224, 233, 242, 255, 265, and 277).

Motor trucks.—In 1919, the Office of Farm Management, whose independent and coöperative studies of tractors have just been discussed, also commenced a study of motor trucks, and continued it through 1922. The first publication (28—910) covered the experience of eastern farmers with motor trucks and was issued in 1920 under the authorship of two staff members of the Office of Farm Management and Farm Economics, with no mention of any coöperation with the agricultural engineers. Names of farmers were obtained through crop reporters of the Bureau of Crop Estimates. A popular presentation (27—1201) of the same data was issued in 1921 as a joint contribution of Farm Management and Agricultural Engineering, under the same authorship. The third publication (28—931), covering the experience of corn-belt farmers, was issued in 1921 under the same authorship but as a joint contribution from the Bureau of Public Roads and the Office of Farm Management and Farm Economics. The title of the senior author had been changed to "agricultural engineer." A popular publication (27—1314) containing additional data was issued in 1923 with the same authorship and the same arrangement of titles. The fifth contribution (28—1254) covered the operation of motor trucks on farms in the New England and central Atlantic States, and contains data obtained in 1920 and 1922. It was issued from

the Bureau of Public Roads, and its author, who was the second author on the previous bulletins and had represented the Office of Farm Management, was now listed as an assistant agricultural engineer of the Bureau of Public Roads. These three department bulletins represent an interesting instance of men starting to work in a unit devoted to economics and continuing to do exactly the same work in a unit devoted to agricultural engineering.

Other power equipment.—One of the duties assigned to the Committee on Farm Power appointed by the Secretary of Agriculture in 1920 was the making of an appraisal of power used on farms in the United States. The studies of tractors and motor trucks which have just been discussed, and which included some comparisons with horse power, were fundamental to the larger study proposed. In 1925, the Committee published results of a coöperative study of all phases of the farm-power problem (15; 28—1348). This *Department Bulletin* was prepared by the Division of Agricultural Engineering of the Bureau of Public Roads, but drew its material from all sources, including the Federal Bureau of Agricultural Economics, the various State agricultural colleges and agricultural statisticians, the Federal Power Commission, the Interstate Commerce Commission, manufacturers of agricultural equipment, farm publications, and interested individuals (*op. cit.*, p. 5).

During 1929 and 1930, the Federal Committee on Farm Power, represented by the Division of Farm Management of the Bureau of Agricultural Economics, the Division of Mechanical Equipment of the Bureau of Agricultural Engineering, and the Division of Animal Husbandry of the Bureau of Animal Industry, coöperated with various divisions of the Experiment Stations of Indiana, Iowa, Michigan, and Missouri in a study of the utilization and cost of power on corn-belt farms. The resulting publication in 1933 was authored jointly by the three Bureaus, and showed the coöperation on the cover and title pages, with a fuller statement on the inside of the front cover (29—384). Similar coöperative studies were made later in Georgia, Mississippi, and South Carolina, and a manuscript was prepared for publication (36—1933).

In 1931, the Committee on Farm Power outlined a project for determining the quantities of different kinds of power used on the farms of the United States. The decreasing numbers of horses and

mules, and the increasing depression, made it highly important to determine the use of mechanical-power and labor-saving implements. Information was derived in part from investigations made by the Department itself and in part from information assembled by the Bureau of the Census in the Department of Commerce and by the State Colleges of Agriculture. The resulting publication (34—157) was issued in 1933 from the Bureau of Agricultural Engineering, and covered the subject of power and machinery in agriculture. The coöperation from numerous Federal and State agencies as well as farm-equipment manufacturers is acknowledged in the text. It was determined that of the 17,000,000,000 horse-power units developed on farms, exclusive of automobile use, about 50 per cent was mechanical power.

Electricity: In 1918, the Division of Rural Engineering of the Bureau of Public Roads prepared a discussion of the feasibility of obtaining electric light and power for farms from small streams (35—1918:221—38). While not coöperative, this investigation is cited to show the increasing interest in electricity on farms at that date. In 1919, a similar publication on the use of electric light and power in the farm home was prepared (35—1919:223—38). In 1925, this article was revised (27—1430), and in 1931 the information was again brought up to date (27—1658). In coöperation with the Virginia Polytechnic Institute, a study was begun, in 1922, of the construction of farm dams and the development of hydroelectric power plants. At the conclusion of the studies in 1923 the results were published.

At a meeting held in Chicago in March, 1923, a Committee on Electricity and its Relation to Agriculture was appointed. The committee originally was composed of representatives of the U. S. Department of Agriculture, the American Farm-Bureau Federation, the American Society of Agricultural Engineers, which represented the engineering divisions of the State agricultural colleges and experiment stations, and finally, the National Electric Light Association. Later, there were added to the Committee representatives of the Federal Departments of Commerce and the Interior. A comprehensive program of investigation was outlined and adopted by the Committee to be carried out by the engineering units of the U. S. Department of Agriculture and the State stations

(50—1923:486). By 1925, no less than seventeen States were engaged in this study (1b—39:318; 21a:318). The Federal Committee on Farm Power, composed of the chiefs of the Bureaus of Agricultural Economics, Public Roads, and Animal Husbandry, was requested to make a survey of the use of power on farms and of the agricultural use of electricity in foreign countries. The direction of this survey was committed to the Division of Agricultural Engineering of the Federal Bureau of Public Roads. The results, including the use of electricity, were published (28—1348) in 1925, as already noted above.

Similar committees on electricity and its relation to agriculture were created in various States. The California Committee consisted of seventeen persons representing the University of California College of Agriculture, the State Railroad Commission, the California Farm Bureau Federation, and the light and power companies. Within the State, this Committee conducted various investigations in coöperation with the Agricultural Experiment Station, and also coöperated with the similar committees in other States.

The California Agricultural Experiment Station already has published, between 1927 and 1933, about ten papers resulting from the coöperation of the station with the California Committee on the Relation of Electricity to Agriculture. These have covered a wide range of subject matter. Two relate to the dairy industry, including electrical driving of dairy equipment (3—433) and milk cooling by electrical apparatus (3—495). Two successive publications have to do with electric brooders for chicks (3—441; 4—325). Two are concerned with fruit and nuts, one dealing with the precooling of fruits (3—496) and another with walnut dehydration (3—531).

The fourth in the series was prepared by the subcommittee on statistics and dealt with electrical statistics for California farms (4—316).

The tenth, published in 1933, covered mechanical refrigeration for farms (4—329). Several of these were authored jointly by a representative of the subject-matter division concerned and a representative of the Division of Agricultural Engineering. In most cases, the coöperation is fully declared on the inside of the cover page, but in others it appears in a footnote.

Miscellaneous Apparatus and Implements

Engineering studies, both independent and coöperative, have been made in miscellaneous fields which do not relate directly to any of the subsections previously presented. Among these are apparatus for drying such agricultural products as seed cotton, grain, and hay, for cleaning and treating seed grain, for dehulling and scari-fying leguminous seeds, and for the steam-sterilization of soil. Numerous pieces of laboratory apparatus for cleaning, sampling, dehulling, or moisture-testing various grains have been developed at different times by the Division of Grain Investigations of the Bureau of Agricultural Economics, in connection with their work on grain standards, and independently of the agricultural engineers. These devices include, among others, the Bates aspirator, the Boerner sampler, the Brown-Duvel moisture tester, and the Gehl rice scourer.

Cotton-drying equipment.—From about 1928, the Division of Agricultural Engineering, then in the Bureau of Public Roads, has been conducting experiments in the artificial drying of seed cotton. From 1930 onward, most of this work was coöperative with the Federal Bureau of Agricultural Economics, whose Division of Cotton Marketing was vitally interested in the quality of the fiber, and with the Delta Branch Station of the Mississippi Agricultural Experiment Station, where a special ginning laboratory was constructed with Federal funds in 1931. Other investigations were conducted independently. Different types of small units for artificial drying were constructed, and full-sized units were erected later on plantations in Louisiana and Mississippi. Three public patents on equipment and processes were applied for in 1928. A vertical seed-cotton dryer was perfected in 1932 and a public patent was obtained. Construction plans and directions for use were published (34—149).

Grain-drying equipment.—With the advent of the combined harvester-thresher, or combine, in the more humid eastern States, the problem of reducing the moisture content in the grain harvested with this machine was immediate. In 1928, the Federal Division of Agricultural Engineering, in coöperation with the Grain Division of the Bureau of Agricultural Economics, set up and op-

erated a small experimental grain-drying outfit at Fargo, North Dakota, probably in coöperation with the North Dakota Station. This work was a part of the general study of the combine made in coöperation with the Bureaus of Agricultural Economics and Plant Industry. In 1930, studies were continued of a commercial dryer in a country elevator at Parshall, North Dakota. The results were published (32—127) in 1930 under joint authorship of the two Federal Divisions.

In 1930, the Federal Division of Agricultural Engineering began studies on the drying of rice at commercial dryers in Arkansas and Texas, and a preliminary report was issued. This work was coöperative with the Grain Division of the Bureau of Agricultural Economics, and included a study of drying temperatures which would not prove injurious through causing the cracking of kernels. Experiments were continued during 1931 and extended to cover tests of milling qualities. A report on direct harvesting by combine has been prepared, and one on artificial drying of the resulting grain has been published (32—292).

Hay and forage-drying equipment.—In 1929, the Federal Division of Agricultural Engineering began experiments in the artificial drying of hay in coöperation with the Bureau of Plant Industry and the Nebraska Agricultural Experiment Station. In 1931, an experimental forage dryer was installed on the Iberia Livestock Farm near Jeanerette, Louisiana, in coöperation with the Federal Bureaus of Animal Industry and Plant Industry. The tests included both rotary-drum dryers and conveyor dryers. Feeding tests on dairy cattle were made with these artificially dried products in coöperation with the Federal Bureau of Dairy Industry. In 1933, the investigation was extended to include crushing of the forage in the fields and at the dryer, with an especially constructed forage crusher using heated rolls.

Seed-cleaning and scarifying equipment.—Some coöperative studies of grain-cleaning devices were included in the previous discussion of grain-harvesting and threshing machinery. Beyond these, relatively little has been done. In a discussion of cleaning grain on farms and in country elevators, published by the Bureau of Agricultural Economics (27—1542) in 1927, in connection with its work on grain standards, acknowledgment was made to the Bu-

reau of Plant Industry for information on eradication of weeds in grain fields. In 1929, the results of work done jointly on the combined cleaning and treating of seed wheat were published (33—33). This represented collaboration of the Federal Bureaus of Agricultural Economics and Plant Industry and the Federal-State Agricultural Extension Service in California.

In 1933, the Bureau of Agricultural Engineering began coopération with the Bureaus of Agricultural Economics and Plant Industry in the development of devices or methods for removing smut balls from seed wheat with commercially available farm equipment. In the same year, coopération was begun with the Bureau of Plant Industry to develop a method of dehulling (and/or scarifying) leguminous seeds with equipment obtainable on farms. Both disk scarifiers and gravel in a concrete mixer were tested (36—133).

Fruit and vegetable heating and refrigeration.—The problems of the proper cooling, ventilation, and heating of perishable products, such as fruits and vegetables, during transportation from field and orchard to distant markets, are increasingly important as the distance of shipment increases.

In 1923, the Federal Division of Farm-Engineering Investigations began coopération with the Bureau of Plant Industry in the investigation of fruit and vegetable transportation and storage, including pre-cooling before shipment. The engineering work at first was chiefly of an advisory or consulting nature, but covered investigations in different parts of the country and also in Puerto Rico (50—1923:488). In 1924, the coopération included the entire reconstruction of the refrigerator car of the Bureau of Plant Industry to conform with recommendations made by the Department of Agriculture during the World War, and promulgated by the United States Railroad Administration, in its standard specifications for refrigeration cars. In 1925, cooperative investigation of the pre-cooling of fruit to reduce transportation refrigeration was started, and a portable plant designed for the use of the Bureau of Plant Industry.

During 1924 and 1925, the two agencies previously mentioned continued coopération in a study of body icing and ordinary icing in two comparable cars. Body icing is the placing of ice in direct

contact with the lading of refrigerator cars. A chief problem was the determination of the difference in insulation when the car floor became wetted after body icing. In 1926, the two agencies continued the coöperation and were aided by the Interstate Commerce Commission. In 1928, the results prior to 1927 were prepared for publication.

In 1930, the California Experiment Station published (3—496) on the pre-cooling of fresh fruits, and on temperatures of refrigerator cars and warehouse rooms. This resulted from the coöperation of the Divisions of Pomology and Agricultural Engineering at the California Station and the California Committee on the Relation of Electricity to Agriculture.

In 1928, the Division of Agricultural Engineering began co-operative experiments with the Bureau of Plant Industry in the heating and ventilating of cars carrying winter shipments from the Pacific Northwest to eastern markets. The studies included methods of preparing and loading cars, and tests of different heaters. In 1932, tests of other means of protecting fruit shipments during cold weather, including the use of wet shavings on the floor, were made in coöperation with the Bureau of Plant Industry. A very sensitive calorimeter was constructed for measuring the heat of fruits and vegetables.

Orchard-heating equipment.—The problem of protecting orchards, especially citrus orchards, from the damaging effects of frosts has been under investigation for many years. The coöperation of the U. S. Weather Bureau with public and private horticultural agencies in California on the character and placement of heating equipment has been discussed in the chapter on Climate, and in that on Plant Industry. In 1931, the Bureau of Agricultural Engineering of the U. S. Department of Agriculture coöperated in a preliminary study of the operation of oil-burning orchard heaters, particularly with respect to the cause of excessive and objectionable smoke production, on which a report was prepared (50—1931).

Steam sterilization of soil.—The problem of sterilizing soils by the application of steam has been important to horticulturists for a long time in their attempts to destroy insects, fungus diseases, and weed seeds. In 1930, the Federal Bureau of Plant Industry

and the Wisconsin Agricultural Experiment Station published a popular discussion (27—1629) of this subject, primarily from a standpoint of tobacco growing. In 1932 and 1933, the Bureau of Agricultural Engineering conducted coöperative experiments on steam sterilization of soil in greenhouses and tobacco seedbeds, in coöperation with the Naval Engineering Experiment Station at Annapolis, Maryland, and a publication was issued (29—443) in 1934. The work was done there because steam was available in ample quantities and at a wide range of pressures and temperatures.

The publications listed in the Literature Cited at the end of this chapter which have been cited in this section on Farm Machinery and Apparatus are Nos. 1b, 3, 4, 6, 7, 15, 17, 18, 19, 21a, 24, 26, 27, 28, 29, 30, 32, 33, 34, 35, 36, 39, 40, 41, 47, 48, 50, and 53.

7. FARM STRUCTURES

THE TERM "FARM STRUCTURES," as used here, is much broader in scope than merely farm buildings. It includes substantially all that farm equipment which cannot properly be classed as machinery, implements, tools, or apparatus. It covers farm buildings of all kinds, including dwellings, barns, special houses for poultry, hogs, dogs, and rabbits, sheds, granaries, corn cribs, warehouses, tobacco barns, milk houses, ice houses, greenhouses, silos, water tanks, storage houses for vegetables, and root cellars. The term includes also such supplementary structures as fences, gates, feedlot equipment, breeding and shipping crates, and all protective construction designed to prevent injury by rodents, termites, water, or fire. It includes also such supplementary installation as heating plants, water systems, sewage systems, light and power systems, lightning rods, telephone lines, and various household and barn conveniences. In short, the term covers all structures and construction on farms except those directly concerned with drainage and irrigation operations and erosion control.

DEVELOPMENT OF STRUCTURES STUDIES

State agricultural experiment stations began to give attention to farm structures soon after their organization. Approximately one third of them had published in this field by the end of the last

century. Most of these early publications, however, were concerned with silos, then new but rapidly gaining in favor. Smaller numbers were devoted to barns and other structures. Within the next few years the scope of the work undertaken by the State stations was greatly enlarged. In practically all of this early work, there was only local coöperation, or some within the individual institution. The Federal program started still later.

In 1901, the Secretary of Agriculture (26—1901:88-89) recommended to the Congress that the Department begin to occupy the field of agricultural engineering. From 1902 until 1905, both the Secretary (26) and the director of the Office of Experiment Stations continued to advocate this program before Congress, including attention to farm structures. Their action was consequent on recommendations made by the Committee on Rural Engineering of the Association of American Agricultural Colleges and Experiment Stations, submitted and approved in 1903. Although the Secretary, in 1904, stated that many recently built and expensive barns had not been properly ventilated, and therefore had promoted the development of tuberculosis among high-priced dairy herds, the Congress apparently was not favorable to investigations of farm structures, but granted a small sum for studies of farm machinery. Apparently, therefore, the net result of these endeavors was a minor coöperation with the Iowa and Wisconsin Stations on the cost and value of reinforced concrete and cement for farm structures, conducted as a sideline to the authorized studies on irrigation and drainage (39—1905:491). No mention of farm structures was made in 1906 or 1907.

The Office of Farm Management, created in the Federal Bureau of Plant Industry in 1906, began studies of one aspect of the farm-structure problem in 1908, and continued them through the fiscal year 1913. This apparently was the result of an official transfer of agricultural engineering other than irrigation and drainage activities from the Office of Experiment Stations to the Office of Farm Management. This unit, however, did not deal with machinery and structures as such, but took account of the relations between both and the profitable operation of farms. These studies, apparently not coöperative with the experiment stations, dealt in general with the character and cost of equipment found on

selected farms under consideration. One such study, published in 1914, was an extensive discussion of water supply, plumbing, and sewage disposal, for country homes (28—57), and another, issued in 1916, covered the cost of fencing farms in the Middle West (28—321). On July 1, 1915, these lines of work, sometimes referred to as the Farm Equipment Section and the Section on Rural Architecture, were transferred to the Office of Public Roads and Rural Engineering, along with irrigation and drainage investigations from the Office of Experiment Stations.

Much attention has been given to the use of concrete in supplementary construction on the farms. In 1911 and 1912, the results of independent studies by the Federal Office of Public Roads and the Bureau of Animal Industry were published (27—461 and 481). In 1922, and again in 1926, the Division of Agricultural Engineering in the Bureau of Public Roads published on different phases of the use of concrete in construction on small farms (27—1279 and 1480).

Coöperating Research Committees and Conferences

In 1927, a group of agricultural engineers met in Chicago to consider methods of obtaining closer coöperation between institutions and individuals, and a stronger research program on farm structures. A committee on research development in farm structures, headed by the chief architect of the Federal Division of Agricultural Engineering, was requested to compile certain information. This comprised references to published material of value to investigators, a list of projects in farm structures and related research in progress in the State agricultural colleges and experiment stations, and, finally, a list of suggested research problems relating to farm structures and equipment. These data were compiled and distributed to those members of the American Society of Agricultural Engineers who were interested in farm structures.

At the meeting of the Society in 1928, the Structures Division adopted resolutions asking the Secretary of Agriculture to organize a survey of the situation regarding research on farm structures. The expressed desire of the Division was that the survey should determine the active research projects at the various institutions, list the existing research facilities in personnel and physical equip-

ment, prepare a comprehensive list of research projects in this field, formulate a national program for stimulating and coördinating the work of the different institutions, and prepare a plan for the dissemination of the information obtained.

The project was endorsed by representatives of several of the land-grant colleges and universities as well as by industries interested in farm structures. The Secretary of Agriculture thereupon authorized the organization of the project and invited various agricultural, commercial, and technical associations to nominate representatives to act in an advisory capacity. Those nominated, together with the respective chiefs of the Division of Agricultural Engineering, the Bureaus of Home Economics and Public Roads, and the Office of Experiment Stations, all of the Federal Department of Agriculture, were appointed by the Secretary of Agriculture as an Advisory Council on Research in Farm Structures.

The chief of the Bureau (then Division) of Agricultural Engineering was made chairman of the Council. The assistant chief of the Agricultural Engineering Section of the Iowa Experiment Station was appointed director of the survey, which was conducted for fifteen months, beginning in June, 1929. A discussion of this national program for the survey and coördination of farm-structures research was presented by a representative of the Division of Agricultural Engineering of the Bureau of Public Roads at the November meeting of the Association of Land-Grant Colleges and Universities (1b—43:191-96) in 1929. A comprehensive report was prepared and published (34—133) in April, 1932. With reference to a national program the findings were (p. 37) that "housing problems are regional, seldom local or national; efficiency in farm-structures research necessitates national leadership; close coöperation should be maintained between State and Federal-research organizations; and the United States Department of Agriculture is preëminently in a position to initiate and carry on a coördinated program."

In May, 1930, the Advisory Council recommended to the Secretary of Agriculture that an adequately trained agricultural engineer in the Division of Agricultural Engineering be designated to organize and direct a national program of coördinated research on farm structures, to foster active coöperation between national and

State institutions, and to maintain intimate contact with the workers in the State colleges and experiment stations, on the one hand, and the industrial, technical, and educational agencies, on the other. For the latter purpose, they recommended a permanent advisory council (*op. cit.*, p. 37). One of the immediate results of the survey was a compilation by the Bureau of Agricultural Engineering of an extensive bibliography relating to farm structures (34—125).

In December, 1931, the President's Conference on Home Building and Home Ownership was held in Washington, D. C. The conference created a very large number of committees to deal with the many phases of the problem. The committee members were selected from Federal and State administrative and research organizations and from the leadership of civic, agricultural, commercial, and technical organizations in the fields of agriculture, architecture, economics, engineering, landscape design, public health, and social welfare. The Committee on Farm and Village Housing, for instance, contained many representatives from the U. S. Department of Agriculture and the State colleges of agriculture, including the chief of the Bureau of Agricultural Engineering of the U. S. Department of Agriculture.

The Farm-Structures Section of the Division of Agricultural Engineering prepared mimeographed circulars for the use of the Conference, one discussing foundations for farm and village houses. The Bureau of Agricultural Economics prepared an extensive bibliography of recent material on farm and village home building and ownership, including construction, protection from fire and insect injury, and the installation of water, heating, electric, and sewage systems (23). The findings of the Conference were published in a series of eleven volumes (22), three of which were concerned with Farm and Village Housing, Housing and the Community, including home repair and remodeling, and Housing Objectives and Programs, volumes 7, 8, and 11, respectively.

FARM BUILDINGS

As we have seen previously, no continuous or consolidated agency was charged with agricultural engineering until the creation of the Division of Rural Engineering in the Office of Public Roads

and Rural Engineering on July 1, 1915. As a result, many separate agencies worked and published independently on the engineering problems involved in their own subject-matter investigations, both before and some years after the year mentioned. Nowhere was this more evident than in matters relating to farm buildings and supplementary farm structures. For instance, the Federal Bureau of Plant Industry published independently on ice houses (27—475) in 1911, on potato-storage houses (27—847) in 1917, and on greenhouse construction and heating (27—1318) in 1923. The Animal Husbandry or Dairy Divisions of the Bureau of Animal Industry published independently on home-made silos (27—589) in 1911; on ice houses for dairy farms (27—623) and plans for small dairy houses (27—689), both in 1915; on self-feeders for hogs (27—906) and pit silos (27—825), both in 1917; on hog-breeding crates (27—966) in 1918, on brooder coops and appliances (30—13), poultry houses (30—19), and hog crates (30—46), all in 1919; again on poultry houses (27—1113) in 1920, on dairy-barn construction (27—1342) as late as 1923, on poultry-house construction (27—1413) in 1924; and, finally, on poultry houses and fixtures (27—1554) as late as 1928.

In the meantime, coöperation was developing. By 1918, publications began to appear in which the agricultural engineers had a part. By 1921, coöperation was rather general. Increasing standards of quality for farm crops and farm livestock and their products, and rising standards of living, made necessary a continuing equivalent improvement in farm structures.

By 1922, these problems had increased beyond the ability of the State colleges and the Department of Agriculture to render adequate service. The college section of the American Society of Agricultural Engineers appointed a committee, including one representative from the Division of Agricultural Engineering in the Federal Bureau of Public Roads, to study these new problems. A scheme was developed for the interchange of building plans and specifications, no matter by what institution prepared. In 1924, a list of all farm-building plans, prepared by all of the colleges and by the Agricultural Engineering Division of the Bureau, was issued by the latter, and revised as needed thereafter, to include more recent drawings and bulletins. A plan of coöperation was

developed to make mutually available all plans that were suitable for use in more than a single State.

Barns and Houses

In 1921, the Federal Division of Farm Management and Farm Economics, in coöperation with the Division of Agricultural Engineering of the Bureau of Public Roads, published on plans for rural community buildings (27—1173). In 1926, the Division of Agricultural Engineering published independently on rammed earth walls for buildings (27—1500), and continued studies on methods of waterproofing such walls. In 1934, the Division published independently on adobe or sun-dried bricks for farm buildings (27—1720).

In 1923, the Divisions of Animal Husbandry and Agricultural Engineering published under joint authorship on the construction of beef-cattle barns (27—1350), and in 1926 similarly on hog houses (27—1487). In 1923, the Bureau of Biological Survey and the Division of Agricultural Engineering issued jointly a *Leaflet* on building rabbit houses (33—15). In 1931, the Division of Agricultural Engineering published suggestions for the improvement of old dairy barns built in banks (32—166), and in a footnote acknowledged the assistance of the Federal Bureau of Dairy Industry, the Department of Farm Machinery of the Pennsylvania State College, and the Philadelphia Interstate Dairy Council.

In 1931, the Forest Service, in coöperation with the Wisconsin Agricultural Experiment Station and the Federal Bureau of Agricultural Engineering, published on the bracing of farm buildings (33—77). In the next year two Divisions of the Bureau of Agricultural Engineering coöperated in a publication on the construction of farm buildings for wind resistance (33—87).

The convenience and efficient operation of the farm kitchen has had considerable attention from Federal agencies for a number of years, but has not been made the basis of much coöperative research. Several Federal publications have contained the suggestions made on the basis of the studies conducted (27—607, 927, and 1513; 30—189). In one of these there was a measure of coöperation between Federal and State agricultural extension workers. A study of floors and floor coverings (27—1219) was published in 1921.

A research project on means of increasing efficiency and comfort in the farm home grew out of the President's Conference on Home Building and Home Ownership. It was begun in 1932 by the Section on Farm Structures, Bureau of Agricultural Engineering, in coöperation with the Bureau of Home Economics. In 1933, a survey of farm-house conditions was made in Alabama, Georgia, Michigan, Ohio, North Carolina, and South Carolina, in coöperation with representatives of the State agricultural experiment stations and extension services. Farm buildings constitute one of the largest items of capital investment in agriculture. The census value in 1930 was approximately \$13,000,000,000. The average value of the farm home throughout the country was only about \$1500. New construction and renovation had been proceeding very slowly because of economic conditions in agriculture. Were 100,000 farm houses built each year, more than sixty years would be required to replace those in use. As a result of the survey, plans were developed in 1933 for designs of farm houses embodying specifications for increased efficiency, convenience, and comfort.

Ventilation of farm buildings.—With the improvement of breeds of dairy cows and their capacity for milk production, dairy-barn conditions began to receive proportionate attention. As early as 1895, the Iowa Agricultural Experiment Station published on the construction and ventilation of dairy barns (13—27). In 1904, the Secretary of Agriculture had pointed out that poor construction of recent dairy barns housing valuable dairy herds had resulted in the destructive spread of tuberculosis. No particular coöperative activities, however, in this field of agricultural engineering seem to have developed for many years.

In 1921, the Committee on Farm-Building Ventilation of the American Society of Agricultural Engineers arranged for a coöperative Federal-State investigation of the ventilation of barns. The studies, which included the temperature effects of ventilation, were conducted through a period of years by the Federal Division of Agricultural Engineering in coöperation with several State experiment stations. A *Farmers' Bulletin*, discussing the principles of dairy-barn ventilation (27—1393) was published in 1924, and a comprehensive bulletin embodying the technical results (29—187) appeared in 1930. In the latter, the coöperation is indicated

in text and footnote (page 2), and the Agricultural Experiment Stations of New York (Cornell University), Massachusetts, Michigan, and South Dakota, are named as coöperating agencies.

In 1931, a coöperative study was begun of the relation of conditions of stable air to milk production, covering particularly the effects of sudden changes in temperature, and the possibility of their prevention by insulation. The investigation was made by the Division of Agricultural Engineering, in coöperation with the Bureau of Dairy Industry of the Department of Agriculture and the College of Agriculture of the University of Wisconsin. The study was continued during 1932, and the results published by the Department.

Protection of farm buildings.—Numerous studies of methods of protecting farm buildings have been made by Federal and State agencies. These investigations have covered such subjects as painting (27—1452), fire prevention, lightning prevention (27—1512), making cellars dry (27—1572), prevention of termite damage (27—1472; 33—31), and rat-proofing construction. The publications cited and others not mentioned have been independent contributions of the Federal Bureaus of Chemistry, Entomology, Public Roads, and Weather. Similar State publications have been issued.

In a few cases, studies of protection of farm buildings have involved the coöperation of two or more Federal agencies. In the matter of fire prevention on the farm, three Federal bureaus, Agricultural Economics, Public Roads (Division of Agricultural Engineering), and Chemistry, have coöperated in studies and publications (27—1590 and 1643) on preventive construction. A discussion of rural community fire departments was published (27—1667) in 1931 by the Bureau of Agricultural Economics with some advisory assistance from the Bureau of Chemistry. A study of construction methods necessary to make farm buildings proof against rats was conducted coöperatively by the Division of Agricultural Engineering and the Bureau of Biological Survey and the results published (27—1638) in 1930.

Storage Structures

Buildings for the storage and treatment of various agricultural products are of increasing importance on the farm. These include

buildings for the storage of vegetables, grain, milk, ice, etc. Attention already has been called to publications in this field issued independently by various Divisions of the Federal Department of Agriculture.

Potato and sweet-potato houses.—As early as 1917 the Bureau of Plant Industry and the Bureau of Markets collaborated in a study of potato-storage houses and the publishing of a popular discussion of them (27—847). From 1928 onward, the Division of Agricultural Engineering in the Bureau of Public Roads coöperated in experiments on various problems of potato storage. Many of the studies were made at the Presque Isle Potato Substation in Maine in coöperation with the Maine Agricultural Experiment Station and the Federal Bureau of Plant Industry. The engineering side of the work covered the requirements and construction of potato-storage houses.

For many years the Division of Agricultural Engineering has coöperated with other units in the problems of sweet-potato storage. In 1918, a popular discussion of sweet-potato storage was published by the Bureau of Plant Industry (27—970), the plans and lists of needed materials being prepared by the Division of Rural Engineering. After several years of such coöperation, the Division collaborated with the Bureau of Markets in 1920 in the wide distribution of sets of plans for the construction of sweet-potato storage houses (50—1920:527). In 1922, the Bureau of Plant Industry and the South Carolina Experiment Station collaborated in publishing a popular discussion of utilizing tobacco barns for sweet-potato storage (27—1267). In 1925, the Division and the Bureau of Plant Industry issued another popular bulletin (27—1442) on storage for sweet potatoes. In 1928, the Division of Agricultural Engineering began coöperation with the Virginia Polytechnic Institute and the Virginia Truck Experiment Station at Norfolk in field studies on the handling of sweet-potato storage houses in Virginia and adjacent States. A report was completed.

Granaries and corn cribs.—The increasing use of large-scale machinery has developed new problems of grain storage on farms. Grain harvested with the combined harvester-thresher has a higher moisture content than grains threshed after standing in shock or stack. The safe storage of this moist grain is a difficult problem

and is conditioned on adequate ventilation. The Federal Bureau of Agricultural Engineering, in coöperation with the Grain Division of the Bureau of Agricultural Economics and the Division of Cereal Crops and Diseases of the Bureau of Plant Industry, has studied this problem for the past several years. Some of the results and suggestions will be found in the series of publications cited above in the discussion of machinery for harvesting small grains, corn, and grain sorghum in the section on farm machinery. Other discussions were separate from those concerning combine harvesting (27—972).

Numerous studies were made of the question of handling the grain from the combined harvester-thresher in bags or in bulk. Some were published independently by the Grain Division of the Bureau of Agricultural Economics (27—1290). More recent publications represent coöperation between that Bureau and the Agricultural Experiment Stations of Idaho, Oregon, and Washington, and with State Grain-Inspection Departments (32—161).

The question of bulk storage of grain on farms has received considerable recent attention. In 1929, the Division of Grain Investigations of the Bureau of Agricultural Economics and the Division of Agricultural Engineering of the Bureau of Public Roads collaborated in a discussion of the problems of grain storage on farms (33—46). In the following year, they jointly issued a popular bulletin (27—1636) on this subject. An independent study of corn cribs, suitable for use where machine harvesting of corn is practiced, was published by the Federal agricultural engineers (27—1701) in 1933.

Milk and ice houses.—As previously noted, the Dairy Division of the Federal Bureau of Animal Industry published independently on dairy houses, as did the dairy divisions of many State agricultural experiment stations. Coöperation developed later. In 1921, the Federal Dairy Division published independently on farm-dairy houses (27—1214) but stated that blueprints for their construction could be obtained from the Division of Agricultural Engineering in the Bureau of Public Roads. In 1932, the Bureau of Dairy Industry, with assistance from the Bureau of Agricultural Engineering in preparing floor plans, published on small plants for pasteurizing milk (32—214).

In 1920, the Federal Dairy Division and the Division of Agricultural Engineering collaborated in a popular publication on the harvesting and storing of ice on the farm (27—1078).

SUPPLEMENTARY STRUCTURES

At the beginning of the discussion of farm buildings, mention was made of numerous investigations of farm structures, including minor or supplementary structures, made by Federal units not concerned with agricultural engineering. Between 1917 and 1919, there appeared independent publications concerning such supplementary structures as self-feeders for hogs (27—906), hog crates (27—966; 30—46), and brooder coops and appliances (30—13). In recent years, the Division of Animal Husbandry of the Federal Bureau of Animal Industry has collaborated with the Division of Agricultural Engineering of the Bureau of Public Roads in studies and publications on hog-lot equipment (27—1490) and feed-lot and ranch equipment for cattle (27—1584), the latter published in 1929.

A similar type of coöperation between the Animal Husbandry and Agricultural Engineering Divisions with the Iowa Agricultural Experiment Station on dairy stalls resulted in the publication of a research bulletin (14—150).

AUXILIARY INSTALLATIONS

Much attention has been given by engineering and other agencies to the problems of auxiliary installations of many kinds on the farm. These include heating apparatus, refrigeration plants and appliances, water supplies and systems, sewerage systems, light and power plants, and telephone lines and equipment. Most of the studies made have been conducted independently, but in a few cases coöperative relations have developed.

Heating Plants and Apparatus

As early as 1920, the Federal Division of Agricultural Engineering published an independent study of one-register furnaces (27—1174). In 1921, they published independently on the operation of home heating plants (27—1194) and on chimneys and fireplaces (27—1230), the latter being revised and issued as a new bulletin (27—1649) in 1931.

In 1924, the Federal Division of Agricultural Engineering, in coöperation with the Bureau of Home Economics, began a study of the efficiency and operation of oil burners for domestic heating. In the next year, a laboratory was equipped at the Arlington Experiment Farm and fifteen different makes of burners were tested. The results were published by the Department (30—405) in 1927, and a revised edition issued in 1930. In 1929, the Division published also the results of a study of the oil burner as applied to domestic heating (29—109). In neither publication was there any reference to the earlier coöperation with the Bureau of Home Economics. In 1933, a *Farmers' Bulletin* (27—1698) on the heating of the farm home was issued. This represented a revision of the two publications which appeared in 1920 and 1921. In the same year, a comprehensive study of modern vaporizing domestic oil burners was undertaken.

In 1929, the Division of Agricultural Engineering began a survey of greenhouse operation, including especially the heating requirements with reference to climatic influences. The results of this independent study were published (32—254) in 1932.

Refrigeration Plants and Apparatus

The two principal lines of investigation in refrigeration are concerned with plants for the handling of dairy products and with the transportation and storage refrigeration of fruits and vegetables.

Dairy-plant refrigeration.—In 1929, a joint survey of the efficiency and economy of small refrigerating systems on dairy farms was begun by the Federal Bureau of Dairy Industry and the Division of Agricultural Engineering. This work was continued for several years, and covered studies of both ice-operated and mechanically operated cooling units and other refrigeration for dairy farms. The results were published (34—138) in 1932.

In California, different State agencies coöperated in similar studies. In 1925, the Division of Agricultural Engineering at the California Station published a circular on milk houses for California dairies (4—286), in which assistance was acknowledged from members of the staff of the Station Division of Dairy Industry and the Bureau of Dairy Service in the State Department of

Agriculture. A second and similar publication (4—495), issued in 1930, was coöperative between the State Experiment Station and the Committee on Dairy Refrigeration of the California Committee on the Relation of Electricity to Agriculture.

Controlled temperature chambers.—In 1924, the Division of Agricultural Engineering, in coöperation with the Bureau of Plant Industry, devised a chamber with controlled temperatures suitable for freezing fruit on the trees, in order to study frost injury to citrus fruit in California.

Water, Sewerage, and Power Installations

In 1914, the editor and abstractor of the literature of agricultural engineering for the *Experiment Station Record*, abstracting journal of the Federal Office of Experiment Stations, prepared a comprehensive bulletin (28—57) on water supply, plumbing, and sewage disposal for country homes. This was a compilation of all the information made available through State and Federal studies and publications.

As early as 1918, the Federal Division of Rural Engineering published an independent popular discussion of water systems for farm homes and in 1925 a revision of it (27—1448). In 1922, the Division published independently on sewage and sewerage of farm homes (27—1227), including material from boards of health. In 1924 and 1925 the Division published on various aspects of farm plumbing and its repair (27—1426 and 1460). In the meantime, minor coöperation with other agencies had developed. The relations which occurred in studies on the development of farm light and power plants by the damming of farm streams already have been discussed in the subsection on tractors, trucks, and other power equipment, in the section on Farm Machinery and Apparatus.

In 1917, the Division of Agricultural Engineering of the Federal Office of Public Roads and Rural Engineering coöperated with the North Carolina College of Agriculture in making plans for septic-tank installation on one of the State test farms. In 1924, the Division, in coöperation with the Office of Coöperative Extension Work, prepared a series of lantern slides on farm sanitation, and an accompanying syllabus to be used by the lecturer showing

the slides. In 1930, the Division made a survey of numerous installations to obtain data on the design and operation of different types, and to determine the causes of failure.

The publications listed in the Literature Cited at the end of this chapter which have been cited in this section on Farm Structures are Nos. 1b, 4, 13, 14, 22, 23, 26, 27, 28, 29, 30, 32, 33, 34, 39, and 50.

8. SUMMARY OF COÖPERATION

THREE FACTS STAND OUT prominently in a survey of the development of studies in agricultural engineering. The first is that relatively little was done in this country in the field of drainage engineering, farm machinery and apparatus, or farm structures except silos, until after the end of the last century. This was long after the development of large-scale activities in animal and plant industry, chemistry, soils, climate, and the conservation of natural resources.

The second fact is that the investigations, except irrigation engineering and part of drainage engineering, developed in other subject-matter units rather than in the engineering units. This was true both in the Federal Government and in the States. Thus studies in farm machinery, greenhouse construction and heating, storage structures, transportation refrigeration and heating, and drying apparatus were first given attention by farm-crop specialists. In the same way, investigations of such farm structures as silos, barns, dairy barns, milk houses, poultry and hog houses, and ice houses were developed chiefly by workers in animal husbandry and dairying. Terracing was developed by farmers and farm-crops workers, and erosion studies by soil technologists. Explosion-prevention engineering, both with relation to structures and to machinery, was developed almost entirely by chemists, with assistance from plant pathologists, and protection from lightning was given earliest attention by meteorologists.

The third fact is that many of these various subject-matter units kept on with their former engineering activities long after engineering units were formed in their respective institutions. Some of the earlier relations with the engineers developed when these other units needed detailed plans and specifications for complex appa-

tus or structures. Naturally, they found the engineers better able to prepare the technical drawings.

Relations developed earliest between the farm-crops and animal-husbandry units on the one hand and the engineering agencies within the various State agricultural colleges and experiment stations on the other hand. The close proximity of such groups in most State institutions and the consequent more frequent contacts and better knowledge of each other's activities probably have helped to develop coöperation. Their geographic field, also, is smaller. In the Federal Department of Agriculture, the consolidation of engineering activities in the present unit is less than twenty years old. The various research units often were far separated physically until after the recent building program. Furthermore, an engineering problem might confront a crop or livestock specialist hundreds or even thousands of miles from Washington or from any representative of the engineering unit.

Many effective relations have developed in recent years between Federal and State agencies, and between different units of the Federal Government. Most of these center around recently developed or expanded projects of wide scope. In drainage engineering numerous extensive coöperations have developed between Federal drainage engineers and State agencies, drainage districts, and county supervisors. In erosion engineering, there is the enormous Federal-State coöperative project in establishing and maintaining the national system of erosion experiment stations in agricultural and forest areas.

Typical examples of coöperation in studies of farm machinery are those concerned with corn-borer control, those conducted by the Committee on Farm Power, and those concerned with the operation of the combined harvester-thresher under humid conditions. In the field of farm structures, numerous but less extensive relations have developed.

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16. Merritt, Dixon. Department of Agriculture in the war. 208 p., mime., 8½" × 11". U. S. Dept. Agric., Press Service, about 1920.

17. Minnesota Agricultural Experiment Station. Bulletins 1-, 1888—.

18. Nebraska Agricultural Experiment Station. Bulletin 1-, 1888—.

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26. U. S. Department of Agriculture. Report of the Secretary of Agriculture for the year ———. 1862-.

Report of the Commissioner, 1862-88; Report of the Secretary, 1889-. From 1862 to 1920, inclusive, and for 1922 and 1923, the reports of Chiefs of Offices, Divisions, and Bureaus are included with the report of the Secretary in a consecutively paged volume. For 1921 and 1924 to date, all these reports are issued separately each year, with separate paging. (See also *Yearbooks*.)

27. U. S. Department of Agriculture. Farmers' Bulletins 1-, 1889-.

28. U. S. Department of Agriculture. Department Bulletins 1-1500, 1913-29.

All Bureau series of publications were discontinued on June 30, 1913, and various Departmental series started on July 1. This series of *Department Bulletins* was succeeded by *Technical Bulletins* and *Miscellaneous Publications*, the issuance of which, however, began in 1927. The *Department Bulletins* are designated simply as "Bulletins" until after No. 1100, when the word "Department" was inserted.

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30. U. S. Department of Agriculture. Department Circulars 1-425, 1919-27.

They should not be confused with the series known as *Miscellaneous Circulars*, established in 1923 and still issued, or with the series designated simply as *Circulars* (Nos. 1-, 1927-).

31. U. S. Department of Agriculture. Miscellaneous Circulars 1-, 1923-.

This series should not be confused with the series designated as *Department Circulars* (Nos. 1-425, 1919-27), or with the series designated simply as *Circulars* (Nos. 1-, 1927-).

32. U. S. Department of Agriculture. Circulars 1-, 1927-.

Circulars in this series should not be confused with those in the series designated as *Department Circulars* (Nos. 1-425, 1919-27), or with those in the series designated as *Miscellaneous Circulars* (Nos. 1-, 1923-).

33. U. S. Department of Agriculture. Leaflets 1-, 1927-.

34. U. S. Department of Agriculture. Miscellaneous Publications 1-, 1927-.

The different publications in this series range in size from 16mo or smaller up through 12mo, 8vo, and 4to, which means that bound sets rarely are complete. This series should not be confused with the concurrent series of *Miscellaneous Circulars*.

35. U. S. Department of Agriculture. Yearbook of the Department of Agriculture, ——— [year]. 1894-.

From 1894 to 1928, the statistical and other data were for the year named in the title and the volume was published in the following year. Beginning with 1930, the year in the title is the year of issue and the contained data are for the previous year, a most confusing condition. Because of this change there is no volume bearing 1929 in its title.

36. U. S. Department of Agriculture, Bureau of Agricultural Engineering. Report of the Chief of the Bureau of Agricultural Engineering. 1932-.

For earlier reports, see Annual Reports, Office of Irrigation Inquiry, 1891-95; Director of the Office of Experiment Stations, 1898-1915; Director of the Office of Public Roads and Rural Engineering, 1916-18; and Chief of the Bureau of Public Roads, 1919-31.

37. U. S. Department of Agriculture, Bureau of Chemistry and Soils. Report of the Chief of the Bureau of Chemistry and Soils. 1928-.

For earlier reports, see Bureau of Chemistry.

38. U. S. Department of Agriculture, Bureau of Dairy Industry. Report of the Chief of the Bureau of Dairy Industry. 1925-.

For earlier reports, see Bureau of Animal Industry.

39. U. S. Department of Agriculture, Office of Experiment Stations. Report of the Director (now Chief) of the Office of Experiment Stations for ——— [year]. 1888-.

For the fiscal years 1916 to 1923, inclusive, the Office of Experiment Stations was a component part of the States Relations Service and its annual administrative reports will be found in the report of the Director of that Service.

40. U. S. Department of Agriculture, Office of Experiment Stations. Annual Report of the Office of Experiment Stations. 1901-12, 1902-13.

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41. U. S. Department of Agriculture, Office of Experiment Stations. Bulletins 1-256, 1889-1913.

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43. U. S. Department of Agriculture, Office of Experiment Stations. List of Bulletins of the Agricultural Experiment Stations in the United States from their establishment to the end of 1920. U. S. Dept. Agric., Dept. Bul. 1199: 1-186, May 26, 1924.

44. U. S. Department of Agriculture, Office of Experiment Stations. List of bulletins of the agricultural experiment stations for the calendar years 19- and 19-.

1921 and 1922. Dept. Bul. 1199, Supplement 1:1-24, 1924.

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1925 and 1926. Dept. Bul. 1199, Supplement 3:1-62, 1927.

1927 and 1928. Misc. Publ. No. 65:1-78, 1930.

1929 and 1930. Misc. Publ. No. 128:1-88, 1932.

1931 and 1932. Misc. Publ. No. 181:1-77, 1934.

1933 and 1934. Misc. Publ. No. 232:1-81, 1936.

1935 and 1936. Misc. Publ. No. 294:1-94, 1938.

45. U. S. Department of Agriculture, Office of Irrigation Inquiry. Annual Reports. 1890-95 (except 1892).

This office was organized by act of Congress, 1890, and abolished 1895, at which time the irrigation investigations were placed in charge of the Office of Experiment Stations.

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48. U. S. Department of Agriculture, Bureau of Plant Industry. Circulars 1-132, 1908-13.

49. U. S. Department of Agriculture, Division of Publications. Bulletins 1-10, 1896-1913.

50. U. S. Department of Agriculture, Bureau of Public Roads. Report of the Chief of the Bureau of Public Roads. 1919-.

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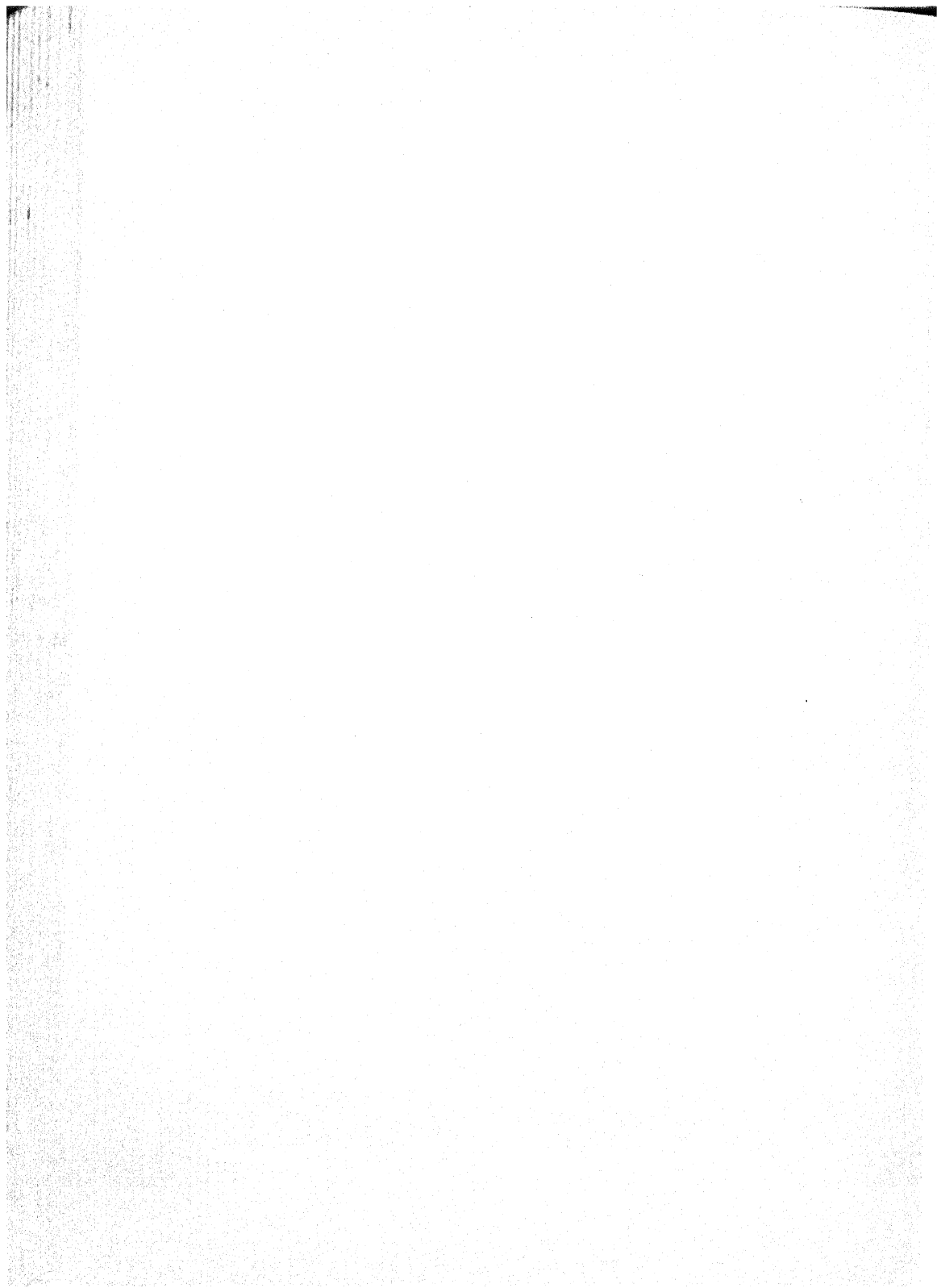
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55. Washington Agricultural Experiment Station. Bulletin 1-, 1891-.

56. Washington Agricultural Experiment Station. Bulletin (Special Series) 1-9, 1909-12.

57. Wiest, Edward. Agricultural organization in the United States. Univ. Kentucky: Studies in Economics and Sociology, 2:i-xxiii, 1-618, 1923. (The Bureau of Public Roads (pp. 49-57), including the Divisions of Irrigation, Drainage, and Rural Engineering.)

58. Wisconsin Agricultural Experiment Station. Bulletins 1-, 1883-.



Chapter IX: AGRICULTURAL ECONOMICS

[Because each chapter covers a different subject and therefore will be used chiefly by a different constituency, it seems desirable to make each one complete and self-contained. For this reason, among others, a complete table of chapter contents is placed at the beginning of each chapter, rather than at the front of the volume. A list of all literature cited in the chapter will be found at the end of the chapter and the numbers in parentheses in the text refer the reader to the corresponding entries in this list. All entry numbers occurring in each major section of a chapter also are listed in numerical sequence at the end of that section, thus forming what is in effect a section list of literature cited. These features all should prove of great convenience to readers.]

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Chapter IX

AGRICULTURAL ECONOMICS

1. INTRODUCTION

AGRICULTURAL ECONOMICS is the most recent phase of agricultural knowledge to be developed, being even newer than agricultural engineering. It has grown more rapidly, however, than any other branch of agricultural science, because great and fundamental changes have been taking place swiftly in the agriculture of America and the world in recent years.

Not all the data of agricultural economics are new. Statistical data, the basis of all economic studies, have been a concern of governments for a long time. Censuses of population, estimates of annual crop production and livestock numbers, compilations of weather data, and figures on exports and imports, for the homeland and foreign countries, all are basic to any study of agricultural economics.

To crop and livestock estimates and other statistical data have been added many recent subjects. The most important of these are outlook reports, farm management, costs of production, standards of product and container quality, marketing methods, market news services, warehousing, agricultural finance, land economics, rural sociology, and now land-use and other planning, on local, State-wide, regional, and national bases.

COÖPERATING AGENCIES

The agencies concerned with agricultural economics are at three levels, international, Federal, and State. Neither county nor city governments have been actively concerned in the past. County governments have now become coöperatively interested, through certain effects produced by depression and other destructive forces such as soil erosion, exploitation of submarginal lands, etc., and are taking an active part in the new planning of land utilization and rural rehabilitation. The major agencies are listed here, but their coöperative relations are discussed throughout this chapter.

International Agencies

The only strictly international agency is the International Institute of Agriculture at Rome, a statistical organization established and financed jointly by the governments of many countries. The Division of Foreign Service of the Federal Bureau of Agricultural Economics, and similar services maintained by other countries, are international in contacts though not in support. The Foreign Service of the Department of State also contributes to the international information available, as does the Bureau of Foreign and Domestic Commerce in the Department of Commerce.

Federal Agencies

Federal agencies now concerned with agricultural economics have developed historically in three major fields, namely, statistics, farm management, and marketing. To these have been added in recent years such specialized subjects as agricultural finance, land economics, and rural sociology.

Federal statistical agencies for agriculture date from 1839, when an appropriation for collecting statistics was first made to the Patent Office. In 1863 a Division of Statistics was established in the new Department of Agriculture, and, in 1903, this Division became a Bureau. In 1914 the name was changed to Bureau of Crop Estimates, in 1921 a merger created the Bureau of Markets and Crop Estimates, and in 1922 it became the Division of Crop and Livestock Estimates in the Bureau of Agricultural Economics.

Farm management studies began in the Bureau of Plant Industry in 1902, and an Office of Farm Management was established in the Bureau in 1906 and was made an independent Office in 1915. The name was changed to Office of Farm Management and Farm Economics in 1919, and it then acquired some activities in agricultural finance, land economics, and rural sociology which had been developing in the Office of Markets and Rural Organization since 1914. In 1922 it became the Division of Farm Management and Costs in the Bureau of Agricultural Economics and its other activities were transferred to new Divisions.

Marketing functions began with the establishment of a largely statistical Section of Foreign Markets in 1894, the name being

changed to Division of Foreign Markets in 1902. Fruit-marketing investigations were begun in the Bureau of Plant Industry in 1906. An Office of Markets was created in 1913, the name being changed to Office of Markets and Rural Organization in 1914. In 1917, it became the Bureau of Markets, and in 1921 two Bureaus were merged as the Bureau of Markets and Crop Estimates. In 1922, with another unit, it became the Bureau of Agricultural Economics.

The Bureau of Agricultural Economics, created on July 1, 1922, was composed of the Bureau of Markets and Crop Estimates and the Office of Farm Management and Farm Economics. Its Divisions may be conveniently arranged in three groups: basic, marketing, and rural economics. The Divisions in the group producing basic data are Crop and Livestock Estimates, Statistical and Historical Research, Farm Management and Costs, and Foreign Service. The Divisions in the marketing group are Cotton Marketing; Grain; Hay, Feed, and Seed; Tobacco; Fruits and Vegetables; Livestock, Meats, and Wool; Dairy and Poultry Products; and Warehousing. The Divisions concerned with what may be loosely called rural economics are Agricultural Finance, Land Economics, and Farm Population and Rural Life.

Units in the Department of Commerce having some activities similar to those of the basic Divisions mentioned above are the Bureaus of the Census and of Foreign and Domestic Commerce. In the Department of Labor, the Bureau of Labor Statistics collects data on subjects related to farm labor.

State and Intrastate Agencies

In general, the history of State agricultural economics agencies has somewhat paralleled that of the units in the Federal Department of Agriculture. Statistical agencies developed first, sometimes in State departments of agriculture and sometimes in the State colleges of agriculture. Farm-management units began to develop as departments in these colleges at about the turn of the century. Marketing units originated somewhat later, partly in the agricultural colleges and experiment stations, partly in State departments of agriculture, and partly as independent State units. Departments of agricultural economics developed slowly in the colleges

after the opening of the present century, and included some or all of the earlier statistical, farm management, and marketing units, except such as were established in State departments of agriculture. Units concerned with rural economics, especially agricultural finance and rural sociology, developed last of all, and usually in the departments of agricultural economics, although sometimes rural sociology was separate.

BIBLIOGRAPHIES AND PROJECTS

The present Bureau of Agricultural Economics publishes a series of agricultural economics bibliographies (99),* now numbering more than fifty issues. They relate to many of the subdivisions of the subject and are cited at appropriate points. A few are concerned with the general subject (99—1) or the recent farm problem (99—23, 27, 50, 51, and 52).

The Federal Office of Experiment Stations compiled for the fiscal year 1931 a classified list of State experiment station projects in agricultural economics and rural sociology. Agricultural economics was subdivided into farm management, cost of production, marketing, prices, agricultural statistics, farm income, coöperation, agricultural finance, farm taxation, land economics, farm labor, and agricultural economics history (102).

2. CROP AND LIVESTOCK STATISTICS AND ESTIMATES

A KNOWLEDGE OF PRODUCTION AREAS, acreages, quantities, and trends for all important crops and classes of livestock is fundamental to the business of agriculture. So, too, is information on prices and price trends. These were the first statistics provided. Next arose the demand for advance estimates of acreage and probable production. Then surveys of production of special crops and, still more recently, outlook reports or estimates of probable demand, were added. Broadening of scope and refinement of methods have kept pace with the steadily increasing complexity of the whole agricultural enterprise.

For convenience, the discussion will be presented under five heads: agricultural production data, special production surveys,

* Numbers in parentheses refer to the Literature Cited, at the end of the chapter.

outlook reports, prices and price analyses, and miscellaneous statistical data.

AGRICULTURAL PRODUCTION DATA

Two major Federal agencies, the Bureau of the Census in the U. S. Department of the Interior and the Bureau of Agricultural Economics in the Federal Department of Agriculture, are concerned with the collection and compilation of agricultural statistics. The gathering of agricultural data by the Census Bureau is more recent than such computations by the predecessors of the Bureau of Agricultural Economics. The census data are discussed first, however, because they are the basis for decennial revisions of findings by the Department of Agriculture.

Bureau of the Census

The Sixth Federal Census in 1840 contained some facts on agricultural production, but it was not until the Tenth Census in 1880 that both acreage and production of crops were tabulated (94—171:4). The data on agriculture obtained in the decennial census are basic, being actual acreages in farms and in cultivation, shifts in the number and size of farms, shifts in rural population, and actual figures for acreage and production instead of estimates in the form of percentages of the acreage and production of the previous year. The results of each decennial census are used by the Crop Reporting Service of the Bureau of Agricultural Economics as a ten-year base line for truing up their percentage estimates of the previous nine years.

Most of the information is obtained by direct inquiry on the part of the enumerators. The six horticultural schedules, however, of the 1930 census, were sent by mail to an extensive mailing list obtained through coöperation with the U. S. Department of Agriculture and with trade organizations in the field of horticulture.

In California, there were 21 supervisors' districts for the purpose of the 1930 census. Of these 7, or one-third, were urban, 2 being in San Francisco and 5 in Los Angeles. The remaining 14 districts were concerned chiefly with rural statistics. For the country at large, each of its 575 districts had an average population of about 213,000 and an average of 208 enumerators. The proportion for California probably did not vary greatly from these figures.

Coöperation with other Federal agencies.—The Bureau of the Census obtains the coöperation of the U. S. Department of Agriculture in the preparation of the agricultural schedules, especially as to new inquiries in the general farm schedule, or new special schedules. Representatives of the U. S. Department of Agriculture have coöperated in obtaining lists of sheep owners in the thirteen western States, including California, where many flocks are migratory, in order that the special sheep schedule might be completely filled.

The U. S. Department of Agriculture, through its field representatives in the States and their counties, coöperates also in distributing sample schedules in advance of the enumeration in order that farmers may be prepared to answer enumerators' inquiries. Postmasters, representing the Post Office Department, also have aided in this work and in furnishing names of recipients for the special schedule on irrigation and drainage.

There is formal coöperation between the Bureaus of the Census and Agricultural Economics in obtaining the record of prices of farm products per established unit (bushel, pound, etc.) which were received by farmers in the individual counties of the country, these prices being used in computing the value of the crops and livestock, and their products, the quantity of which was reported on the farm census schedule. By formal agreement of August 9, 1929, for the Fifteenth Census, each Bureau bore half the cost of obtaining these unit price figures, each Bureau detailing employees and furnishing equipment and supplies. The agreement provided that the work be completed on or before September 1, 1930 (118—1930:13).

Through coöperation with the Federal Office of Indian Affairs, in the Interior Department, employees of that service were appointed as local supervisors and enumerators on many Indian reservations. Through this coöperation it is believed that a more complete enumeration of the Indian population was obtained for the 1930 census than ever before, as well as more complete statistics of agriculture, irrigation, drainage, etc., in Indian reservations.

Coöperation with State and local officials.—Officials of the State agricultural colleges assisted in preparing the tentative farm schedule for the 1930 census. State and county engineers, and

other local officials, coöperated in supplying names to which the new schedule on irrigation and drainage was sent.

Each supervisor was instructed to obtain, without cost to the Census Bureau, through coöperation with the local Federal Business Association, adequate quarters and office equipment if available from any Federal, State, county, or municipal office, or from civic organizations (118—1930:5). For the country as a whole, free quarters were obtained in about two-thirds of the districts and free equipment in one-fourth of the districts. In California, free quarters were obtained for thirteen supervisors out of twenty-one and for an additional special (disbursing) agent. No data on the office equipment furnished are available. The quarters were occupied from January 16 to June 30, 1930, or 5.5 months. Of the fourteen quarters furnished, two were in Federal buildings, six in county or city buildings, five by commercial agencies, and one by the census supervisors themselves. Federal, county, and city co-operation furnished office space for 3.5 years out of a total of 6.4 years of occupation.

Bureau of Agricultural Economics

The present unit of the U. S. Department of Agriculture which compiles agricultural statistics is the Bureau of Agricultural Economics. The work centers in the Divisions of Crop and Livestock Estimates and Statistical and Historical Research. Also, voluminous data on market movements and prices of various commodities are compiled by the different commodity divisions of the Bureau.

A Division of Statistics was organized in the Department of Agriculture in 1863 to carry on the work done previously by the Patent Office. Its annual reports (114—1863—1902) appeared in the Annual Report of the Commissioner of Agriculture from that year forward. This unit became the Bureau of Statistics (116) for the fiscal years 1903—13, the Bureau of Statistics and Crop Estimates (117) for the fiscal year 1914, the Bureau of Crop Estimates (101) for the fiscal years 1915—21, the Bureau of Markets and Crop Estimates (107) for the fiscal year 1922, and the Bureau of Agricultural Economics (98) thereafter. An annual report was issued by each of these agencies for the fiscal years named. Increasingly ample annual statistics have been published in the

Yearbook of the U. S. Department of Agriculture (96). There was little or no coöperation with other official agencies during the early years.

The principal basis for the crop statistics issued by the U. S. Department of Agriculture, as noted previously, is the information collected decennially by the Bureau of the Census. The Crop and Livestock Reporting Service collects information for the intervening years and, since 1912, also has made forecasts of production of certain crops.

The major gathering of information has been by a Federal corps of voluntary reporters or crop correspondents, unpaid except for the receipt of various publications. When the service was reorganized in 1914, full-time agricultural statisticians were appointed in virtually every State.

In 1925, there were 350,000 voluntary correspondents, using 225 different schedules, or a grand total of some 9,000,000 schedules. Half of these correspondents reported to the field offices in the various States and half to the main office in Washington, D. C. Since 1927, the dual reports have been gradually eliminated, except for cotton, and most of the correspondent reports are sent direct to the State statisticians.

The work now includes estimates of crop conditions, crop acreage (including intentions to plant), crop yields, and crop production; farm value of products, gross income, cash income; reports on field crops, cotton, fruit crops, truck and canning crops, livestock, dairy products, and poultry; farm price reports, including annual prices on crops and livestock, monthly prices of crops and livestock sold, and quarterly prices of 175 articles that are bought by farmers. Improved methodology is a continuing objective (89—311).

Federal-State coöperation.—As the economics of agriculture became more important, many States began to gather and publish statistics of agricultural acreage and production. This soon resulted in two separate sets of agricultural statistics for individual States, not always directly comparable and not always in close agreement where they could be directly compared.

This condition led the then Bureau of Crop Estimates to propose to the States that they enter into a coöperative arrangement for

obtaining and disseminating statistical information. The principal objects sought were: (a) to avoid duplication of effort and expense; (b) to obtain more complete information by combined effort; (c) to promote increased public confidence through greater accuracy and more complete agreement in the statistical matter; (d) to promote comparability of State statistics through successive years; (e) to provide additional channels for distributing information; (f) to make the Federal experience and training available to State statistical agencies; and (g) to provide for adequate study of subjects important to individual States or areas but not to the entire country.

Early in 1917, such coöperative arrangements were made with the Wisconsin State Department of Agriculture. This permitted the use of all State sources of information by the Federal field agent in collaboration with the State officials. It covered also the preparation by the Federal Crop Reporting Board of monthly crop reports for Wisconsin, arranged by counties, telegraphed to the State agent, and published immediately by the State Department of Agriculture (101—1917:307).

The number of coöperating States increased from five in 1918, to fourteen in 1919, to twenty-one in 1920, and to twenty-eight in 1922. Substantially all the States which maintained crop-reporting services at that time were included in the coöperation. By 1919, the laws of twenty-one States required assessors to collect statistical data on crops and livestock on farms. Federal coöperation greatly strengthened this service. By 1930, a total of thirty-seven States was included, and the estimated State contributions exceeded \$300,000 annually. In thirty-one of these States, the coöperation was with the State department or board of agriculture, and in six with the State colleges of agriculture. The New England States are handled as a single area with one coöperative headquarters. In Idaho, the expense and labor of collection and publication of these statistics were shared by the Federal Bureau, the State Commissioner of Statistics, the State Agricultural Extension Service, and a farmer organization, the State Farm Bureau (101—1920:416).

Recently the Federal Department of Agriculture has established a series of publications designated *Statistical Bulletins* (88). These

cover a large number of crop and livestock products. For the most part they represent coöperation of the Divisions of Crop and Livestock Estimates, Farm Management and Costs, and Statistical and Historical Research, as well as of the various commodity Divisions, all in the Bureau of Agricultural Economics. A few concerned with prices are mentioned in a later subsection. One, which covered the grade, staple length, and tenderability of cotton from the crops of 1928 to 1931, inclusive (88—40), showed by inside cover statement that the data were obtained by the Division of Cotton Marketing in coöperation with the California State Department of Agriculture and the Agricultural Experiment Stations of Alabama, Arizona, Arkansas, Florida, Georgia, Louisiana, Mississippi, Missouri, New Mexico, North Carolina, Oklahoma, South Carolina, Tennessee, and Texas.

Purely statistical data resulting from Federal-State coöperation also have been published by the States. A few examples illustrate the scope of coöperation. In Georgia, the State Department of Agriculture published (*Bulletin 96*) statistics for 1923, resulting from its coöperation with the State Experiment Station and the Federal Division of Crop and Livestock Estimates.

In Maine, the State Experiment Station published (34—338) the data based on the Federal agricultural census of 1925. These were compiled by the State Department of Agriculture with financial assistance from the Federal Land Bank of that district, and were published at joint expense of the Station and the State Department. In Ohio, four bulletins of the Experiment Station (61—442, 460, 503, and 530) contained agricultural statistics for 1928, 1929, 1930—31, and 1932, obtained and presented jointly by the Department of Rural Sociology of Ohio State University and the Federal Division of Crop and Livestock Estimates.

Federal interdepartmental and interbureau coöperation.—One of the principal continuing coöperations has been with the Bureau of the Census in the U. S. Department of the Interior. The increasing economic importance of agricultural information requires a steady increase in the number and complexity of the agricultural schedules used in the decennial census. The knowledge and experience of the U. S. Department of Agriculture are fully utilized in aiding the Bureau of the Census in the preparation of these sched-

ules. For the agricultural section of the census of 1920, some 50,000 tentative schedules were tested in advance on the crop reporters of the Bureau of Crop Estimates (101—1918:307).

Under agreement between the secretaries of the two Departments, the Division of Crop and Livestock Estimates rendered full coöperation to the Bureau of the Census both in Washington and in the field in the special quinquennial agricultural census of 1925. For nearly four months, practically the entire field force of the Division was placed at the disposal of the Census Bureau. The thirty-eight State statisticians acted as district supervisors. Some assistance was given also in editing schedules before their tabulation (98—1925:14).

In connection with the work of the Bureau of the Census on the decennial census of 1930, the Division of Crop and Livestock Estimates obtained average farm prices by counties for 156 crop and livestock products, and also the inventory values of 30 livestock items (98—1930:14). Later, these two agencies made a special inquiry into prices of forest products sold from farms in 1929, in which they received assistance also from the U. S. Forest Service and the Interstate Commerce Commission (98—1931:17). For the census of 1930, the State statisticians again were appointed special agents of the Bureau of the Census for a coöperative enumeration of range sheep in the western United States.

In obtaining statistics on agriculture in foreign countries, in addition to those obtained through the International Institute of Agriculture, coöperative relations have developed with other Divisions of the Bureau of Agricultural Economics, and with the Division of Foreign and Domestic Commerce in the Department of Commerce. Some data on tobacco likewise are obtained through the records of the Bureau of Internal Revenue in the Treasury Department. In recent years, the data developed by the Division of Crop and Livestock Estimates have been used by the Federal Reserve Banks and by other banks in the Federal system in formulating credit policies. In a similar way, the administration of the Agricultural Adjustment Act requires estimates of acreage, yield, and production by counties, for the basic crop commodities named in the act or subsequently added. The entire staffs of the headquarters office in Washington and some forty field offices of the

Division of Crop Estimates were employed for several weeks in 1933 in preparing these basic data (98—1933:1).

During the period of the World War, and for some months thereafter, the Bureau of Crop Estimates coöperated extensively with many Departments and agencies of the Federal and State governments and with the Federal Congress. Special information was compiled for the Council of National Defense, U. S. Food Administration, Federal Trade Commission, the Military Intelligence Office of the War Department, U. S. Tariff Commission, the War Industries Board, the War Trade Board, the U. S. Shipping Board, and the Committee on Public Information.

International coöperation.—The International Institute of Agriculture, with headquarters at Rome, was established through the efforts of David Lubin, of California. It is supported by the contributions of the numerous adhering nations, including the United States. By 1917, no less than twenty-four regular reports on the crops of the United States were being made annually by cable to the Institute and statistical tables were contributed to its *Yearbook*. In return, besides the printed reports of the Institute, sixteen cablegrams containing crop data from the adhering countries were received, interpreted by the Division of Crop Estimates, and made available to the American press through the Office of Information (101—1917:302). The reports are received through the Department of State, while reports sent to the Institute from the U. S. Department of Agriculture are transmitted through the Department of State over the radio service provided by the Navy Department. A special compilation of foreign agricultural statistics (86—987) was published in 1921.

In recent years, since the establishment of the Foreign Agricultural Service by the Bureau of Agricultural Economics of the U. S. Department of Agriculture, special statistical and survey studies of foreign agriculture have been made and published. Three covered parts of Europe (86—1234 and 1399; 89—37), and one a portion of South America (86—1409). All of these entailed a measure of informal coöperation with official agencies, especially the Ministries of Agriculture in the countries covered by the surveys.

SPECIAL PRODUCTION SURVEYS

In addition to detailed statistics and regular acreage and production estimates by the Federal Division of Crop and Livestock Estimates, special surveys are required from time to time. Some special surveys are made with and for Federal agencies and others in co-operation with official State agencies for common objectives.

Federal Interunit Coöperation

Some special surveys are conducted to obtain data desired by the Division of Crop and Livestock Estimates itself. Others are made by that Division as services to obtain data desired by other Federal agencies. Still others are joint enterprises of two or more Federal units. Examples of all three classes are given below.

The Division obtains the coöperation of the Post Office Department in permitting its rural mail carriers to distribute schedules to selected farmers along their mail routes. For instance, 500,000 schedules were sent to rural carriers in seventeen States in 1922 for reports on pig production and intention to breed. In 1924, there were distributed to farmers through the rural carriers 750,000 acreage cards on which to make various acreage records. The carriers coöperated splendidly also in livestock surveys. This collaboration resulted in a great saving of expense to the government.

The former Bureau and present Division of Crop Estimates has coöperated with many other official agencies by sending to its crop reporters special inquiries for information needed by the other agencies. Among other Bureaus of the Department of Agriculture so aided have been Markets, Plant Industry, Office of Farm Management, and Office of Fertilizer Control. Similar inquiries were made for the U. S. Food Administration. Likewise, a similar service has been rendered to other Divisions of the Bureau of Agricultural Economics, including Farm Management, Farm Population, Rural Life, and Land Economics, and several of the commodity Divisions.

A good illustration of this type of coöperation is afforded by some inquiries made for the Division of Cereal Crops and Diseases of the Bureau of Plant Industry. Schedules to ascertain the geographic distribution and percentage importance of wheat varieties

in the United States, were sent through the Division of Crop Estimates to its crop reporters and the tabulation of resulting data was made by the Bureau of Plant Industry. Two separate inquiries on wheat, based on the census data of 1920 and 1925, were made with a five-year interval (86—1074 and 1498).

Both the second and third types of interunit coöperation are represented by emergency activities. In 1918 and 1919, the Bureau of Crop Estimates coöperated with officials of the Treasury Department, the Department of Agriculture, and the State Agricultural Extension Services in drought-stricken States in connection with loans of funds for the purchase of seed grain (101—1919:327). Similar coöperation has been effected in the numerous drought emergencies occurring since then.

The third type of coöperative Federal relation is represented by those cases where both or all the coöperating agencies desired the resulting statistical data, and where the study made, therefore, was a joint enterprise, rather than a service on the part of one agency. Good illustrations of this type are found in the special surveys of apple, peach, and pear trees by number, variety, and estimated production. These were carried on coöperatively by the Division of Horticultural Investigations of the Bureau of Plant Industry and the Bureau of Crop Estimates, both of the U. S. Department of Agriculture, in the years preceding the World War. The results were published as joint contributions of the two Bureaus, under joint authorship (86—485, 806, and 822) in 1917, 1919, and 1920, with the coöperation stated on covers and title pages.

Federal-State or Intrastate Coöperation

Numerous other special surveys involving coöperative relations have been conducted within the past decade. Some of these properly may be classed as special surveys. Others are partly special surveys and partly statistical compilations. Still others include these two features and also contain data on farm management and costs of production. Several coöperative inquiries belonging in one or another of these three groups are discussed below. Those primarily of a statistical nature have been mentioned previously in the subsection on Agricultural Production Data, and those deal-

ing primarily with farm organization will be mentioned again later in the section on Farm Management and Costs.

No fewer than twenty-three coöperative studies of this kind have been made in California alone, and the results published by the California Agricultural Experiment Station. This large number is due to the great variety and concentration of agricultural products in that State, including, as it does, extensive production of fruits and nuts, truck crops, farm crops, and animal crops and products. Most of these appeared with a supplementary title reading, "California Crops and Prices." More than half of this total number were concerned with fruits and nut crops. Other States have coöperated less extensively.

General agriculture.—A few special surveys have covered general agricultural conditions rather than special industries.

In California, a special survey of the economic problems of agriculture was made in 1929 by the Division of Agricultural Economics of the College of Agriculture, in response to an official request by the State legislature. The report was transmitted by the president of the University of California to the governor of the State and published by the State Experiment Station (5—504) in 1930. It resulted from a series of thirty hearings held throughout the State, and utilized also information obtained from the U. S. Department of Agriculture and other Federal agencies.

In Idaho, such an economic study, made by the State Experiment Station in coöperation with Divisions of the Federal Bureau of Agricultural Economics, the State Department of Agriculture, and other State agencies, was published (24—151) in 1927. More detailed presentations were made of the dairy (24—152), potato (24—153), and poultry (24—154) situations. In Utah, an economic survey made in Washington County, with special reference to fruit and vegetable production and marketing, and published (123—214) in 1928, included an adjacent portion of Nevada and was coöperative with the Nevada Agricultural Extension Service.

In Mississippi, a special survey of agricultural opportunities in southern Mississippi was made by the Experiment Station and Extension Service, the city of New Orleans, the Federal Bureau of Agricultural Economics, and several private agencies, and published (43—1) in 1926. In South Carolina, special agricultural



surveys were made in Columbia (69—243) and Charleston (69—253) areas, with a wide coöperation of Federal, local official, and commercial agencies.

Farm crops.—Coöperative studies have been made in California on alfalfa (5—521), barley (5—512), and wheat (5—502), all the bulletins being authored by extension specialists in agricultural economics. Federal coöperating agencies were the Division of Crop and Livestock Estimates, U. S. Bureau of Agricultural Economics, and the Bureau of Foreign and Domestic Commerce of the U. S. Department of Commerce. In the alfalfa study there was assistance also from the Federal-State Market News Service. State coöperation included the University of California Division of Agricultural Economics. The Food Research Institute of Stanford University assisted in the cereal studies.

Fruits and nuts.—In California, the studies of the economic aspects of the apple industry (5—445), the pear industry (5—452), the prune industry (5—462), the grape industry (5—429), and the walnut industry (5—475) all were written up by the staff of the Division of Agricultural Economics at the California Station.

Bulletins in still another California series on fruits and nuts, confined largely to those having the subtitle "California Crops and Prices," were authored by extension specialists in agricultural economics belonging to the coöperative Federal-State Agricultural Extension Service, and included studies on almonds (5—453), apricots (5—423), cherries (5—488), grapefruit (5—463), lemons (5—460), olives (5—510), oranges (5—457), and peaches (5—547).

Federal agencies coöperating in most if not all of these studies were the Bureau of Agricultural Economics through its Divisions of Crop and Livestock Estimates, Foreign Agriculture Service, Fruits and Vegetables, and Statistical and Historical Research, and the Bureau of Foreign and Domestic Commerce of the U. S. Department of Commerce. In some the Interstate Commerce Commission assisted. The principal coöperating State agencies in the extension studies were the University of California Division of Agricultural Economics and the California county farm advisors. In the economic studies aid was had from intrastate agencies, co-

operating with the California Station, including the Bureau of Standardization, the Division of Markets, and the coöperative Crop Reporting Service, of the State Department of Agriculture, and many county agricultural commissioners. In the studies of pears and cherries, assistance was had also from the State Agricultural Colleges of Oregon and Washington.

The Federal Bureau of Agricultural Economics published bibliographies on the economic aspects of four fruit industries, namely, apple (99—19) in 1927, peach (99—8) in 1925, strawberry (99—28) in 1929, and grape (99—36) in 1932.

Apples: In 1923, the Virginia State Department of Agriculture (127—1) through its Divisions of Agricultural Statistics and Markets, began a survey of the apple and peach industries of Virginia, in coöperation with the Federal Division of Crop Estimates and the Virginia Polytechnic Institute, its Extension Division and county agents. A survey of the apple industry in the New England States was begun in 1925 by the New England Research Council in coöperation with the State agricultural experiment stations. Some from some State stations published (54—223; 68—207 and 226).

In 1927, the Federal Division of Crop and Livestock Estimates, coöperating with State agencies in many of the States, began a nation-wide survey of the numbers, varieties, and ages of commercial apple trees in the United States. Their investigations usually covered a much wider horticultural and economic scope than the specific inquiries made by the Federal Government. Three examples of this coöperation were published by the New York Cornell (57—495), Montana (47—218), and Utah (123—208) Stations. The Montana coöperation included county agricultural agents and that in Utah included the Federal Division of Farm Management and Costs also.

Peaches: The Federal Bureau of Agricultural Economics also made a regional survey of the peach industry at the same time the apple-tree survey was in progress. The coöperative study in Virginia already has been discussed under Apples. The South Carolina survey was made by the Federal Division of Farm Management in coöperation with the State Station (69—239) and the New Jersey study by the State Station with the State Department of Agriculture coöperating (55—452).

Cherries: A study of trends in cherry production in Michigan was published by the Michigan Experiment Station (38—237), with financial and personnel assistance from the Federal Division of Crop and Livestock Estimates, and minor help from the U. S. Weather Bureau.

Truck crops.—In California, coöperative studies have been made on asparagus (5—487) and beans (5—444). These also were authored by extension specialists in agricultural economics and involved about the same coöperative relations as were presented above for fruits and nuts. An earlier study of cantaloupes (5—419), published in 1927, was authored by the University of California Division of Agricultural Economics, and acknowledged assistance from the Federal Bureau of Agricultural Economics. A study of cantaloupe production in Michigan, published by the State Station (38—237) in 1930, acknowledged data from the Chicago Office of the Federal Market News Service and the use of the high school chemistry laboratory from the Benton Harbor school authorities.

In Idaho, the potato situation was analyzed (24—153) through coöperation of the State Station, the State Department of Agriculture, and other State agencies, with various Divisions of the Federal Bureau of Agricultural Economics. In South Dakota, a study of potato production, prices, and destinations, published by the State Station (70—234), was based on data obtained coöperatively with the Federal Division of Crop and Livestock Estimates.

In New Jersey, a special survey of the potato industry (55—454) was published in 1927 under the auspices of a subcommittee on potatoes of the State Agricultural Program Committee representing State research, regulatory, and extension agencies. It was prepared by the Departments of Plant Pathology and Agricultural Economics of the New Jersey Station, and the Bureau of Statistics and Inspection of the New Jersey Department of Agriculture.

Livestock and products.—In California, coöperative studies included the economic aspects of the beef-cattle (5—461), dairy (5—437), dairy products (5—541), sheep (5—473), and swine (5—523) industries. All of these bulletins were authored by the Division of Agricultural Economics at the California Station. The prep-

aration of the one on the sheep industry was shared by the Federal-State Market News Service. Federal agencies coöperating in some or all of these studies were the Bureau of Agricultural Economics in the U. S. Department of Agriculture through its Division of Crop and Livestock Estimates and Market News Service (beef cattle, dairy products, sheep, and swine), Division of Dairy and Poultry Products (dairy products), and the Bureau of Foreign and Domestic Commerce, U. S. Department of Commerce (dairy products and swine). State agencies coöperating were the California State Department of Agriculture through its Bureau of Dairy Control (dairy industry and dairy products) and Division of Animal Industry (dairy products and sheep), and Cattle Protective Service (beef cattle). Other coöperating divisions of the University of California College of Agriculture were Animal Husbandry (beef cattle, sheep, and swine), and Forestry (beef cattle). In the study of dairy products, the Los Angeles County Livestock Department and the Los Angeles, Oakland, and San Francisco Health Departments all took part. The Food Research Institute of Stanford University also assisted in the study of dairy industry.

In Idaho, a detailed presentation of the dairy situation (24—152) published under Federal-State authorship included the coöperation of the State Departments of Dairy Husbandry, Agricultural Economics, and Agricultural Engineering, the State Department of Agriculture, and the Federal Bureau of Agricultural Economics.

A coöperative survey of the dairy industry of Virginia (127—2), was published in 1926. The State Department of Agriculture was represented by three divisions: Dairy and Food, Markets, and Statistics; the Virginia Polytechnic Institute by the Experiment Station and Extension Division; and the U. S. Department of Agriculture by the Bureau of Agricultural Economics and Extension Service.

Four State-published special poultry surveys are noted. A statistical study of the California poultry industry was published by the Experiment Station (5—413) in 1926, with a statement of coöperation received from the State Department of Agriculture, the California Agricultural Legislative Committee, the Federal Bureau of Agricultural Economics, the Federal-State Extension

Service, the U. S. Department of Commerce, and many commercial agencies. The study in Idaho (24—154) corresponded to the dairy survey, the Department of Poultry Husbandry being the co-operating station agency.

A survey of farm production and consumption of poultry in Kansas by the Station Department of Agricultural Economics, in coöperation with the State Board of Agriculture and the Federal Division of Crop and Livestock Estimates, was made in 1928—29, under the joint authorship of the first and last named agencies (31—256). In New Jersey the State Experiment Station (55—457) and State Department of Agriculture coöperatively conducted and authored a poultry study published in 1927.

OUTLOOK REPORTS

Agricultural outlook reports are in the nature of attempts to forecast the condition of agriculture and the demand for agricultural products for a shorter or longer period in advance. In August, 1913, the U. S. Department of Agriculture began the release of certain forecast material of this nature at monthly intervals. This material later was amplified and published in the series of *Farmers' Bulletins* under the title "The Agricultural Outlook," the practice being continued until March, 1915. The first two of these bulletins (87—558 and 560) contained discussions presented by the Bureaus of Statistics, Plant Industry, Animal Industry, and Weather. Thereafter they were issued, without specific authorship, by the Bureau of Statistics and its successor, the Bureau of Crop Estimates.

After the entrance of the United States into the World War, the proper coördination of our entire agricultural enterprise became of the most vital importance. Various Federal and Federal-State agencies were created to supervise different branches of agricultural production and distribution. Among these were various agencies centering in the U. S. Department of Agriculture, including the Committee on Fertilizer Control, as well as the U. S. Food Administration and the U. S. Grain Corporation. Forecasts, or Outlook Reports, covering prospective needs for different agricultural products and recommending production programs adequate to supply these needs, were prepared coöperatively from time to

time. These programs were published in the series of *Circulars* of the Office of the Secretary (112-75, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 103, 107, 108, 123, 125, and 142). Those containing general programs (112-125) were prepared through coöperation of the State colleges of agriculture with the U. S. Department of Agriculture, and this was true also of some dealing with single commodities (112-84). In some cases there was coöperation with the Department of Labor and other Federal agencies.

Following the World War, the condition of the agricultural industry became very critical, as a result of rapid deflation. Redirection of the trends of production of many agricultural goods became necessary. Early in 1923, the U. S. Department of Agriculture began the practice of calling an annual conference of leading agricultural workers, representing the State agricultural colleges and their experiment stations and extension services, together with specialists of the Federal Department. These conferences attempted to evaluate the trends and conditions of agriculture, the probable demand for the crop and animal products of the coming season, and the general acreage or numbers which appeared to be reasonably justified. Promptly after the conference a national outlook report was issued (92-23, 38, 65, and 101; 94-19, 44, 73, 108, 144, 156, and 182). A summarized report for 1931, also, was issued (94-112). In 1925, the Federal Bureau of Agricultural Economics published a bibliography of material on long-time agricultural programs (99-5). More recently, the Agricultural Adjustment Administration is devoting major energy to this problem, with full coöperation from other Federal-State agencies.

The preparation of these outlook reports, covering many commodities for the entire United States, involves close coöperation between Federal and State research and extension workers in agriculture. By 1929, every one of the forty-eight States had participated, and some sent several representatives to the conference in Washington. In return for State coöperation in formulating the national outlook report, the Federal Department of Agriculture gives special attention to aiding the States in their interpretation of the outlook information for regional, state-wide, and county use.

Immediately after the national conference, four or five regional conferences are held in coöperation with the State agricultural col-

leges and serve as training schools for extension and research workers in economics. The State and county meetings usually are held under the auspices of the Federal-State Coöperative Agricultural Extension Service. More than 2500 such outlook meetings were held in 1929 and reached more than 100,000 farmers directly. The State outlook reports ordinarily are published as bulletins or circulars of the State agricultural extension service and more than 200,000 copies are distributed annually. All extension publications are issued as a result of Federal-State coöperation.

With the coming of the general depression in 1929, this type of activity increased in importance. In 1930, the Federal Farm Board made a request to the U. S. Department of Agriculture for outlook data on several farm commodities as a basis for formulating their farm-loan policies. More recently the Agricultural Adjustment Administration has given large attention to this problem and has had the fullest coöperation of all Federal and State agencies concerned, especially the Bureau of Agricultural Economics and the State colleges of agriculture with their experiment stations and extension services.

PRICES AND PRICE ANALYSES

The former Division and Bureau of Statistics of the U. S. Department of Agriculture gave little attention to prices in its series of bulletins and circulars. Even in the recent period from 1901 to 1913 only one of its bulletins (115—18) discussed prices. In the series of *Department Bulletins*, totaling 1500 between 1913 and 1927, only a few (86—514, 515, 594, 696, 755, 999, 1083, and 1480) were concerned with price statistics and none was coöperative.

More recently, compilations of price statistics have appeared in the series of *Statistical Bulletins* of the Department, established in 1923. In 1927, there were issued four bulletins (88—14, 15, 16, and 17) on prices received by producers from 1866 to 1925, each bulletin covering a different section of the country. These compilations have covered a large series of crop and livestock products. They have entailed the coöperation of several Divisions of the Federal Bureau of Agricultural Economics, including Crop and Livestock Estimates, Farm Management and Costs, and Statistical and Historical Research, as well as the various commodity Divisions individually concerned.

A series of four of these bulletins was concerned with stumpage and log prices (88—32, 36, 37, and 44) for the years 1928, 1929, 1930, and 1931—32. The material was compiled by the U. S. Forest Service in coöperation with the Bureau of the Census.

Several State agricultural experiment stations have published compilations of price statistics, but most of them have caused no more than interdivisional coöperation. Some doubtless have made use of the published data of the Bureau of the Census and of the Bureau of Agricultural Economics, and occasionally one makes direct acknowledgment of such sources of information (26—363).

In recent years, the Division of Statistical and Historical Research, in the Federal Bureau of Agricultural Economics, has coöperated with the agricultural experiment stations of several States in statistical studies. In 1927, coöperative research was begun on prices received by farmers for various agricultural products over long periods of years (98—1927:41). The Maryland study, for instance, obtained records of farmers, stores, mills, and old newspapers dating back to 1851. The completed study, authored by a Federal statistician, was published in 1930 by the Maryland Station (35—321), the coöperation being shown in a footnote. A similar study in Virginia covered the years 1801 to 1927, and was published in 1929 by the Virginia Station (126—37) under the authorship of a joint employee and with the coöperation shown on the cover.

The Federal Bureau of Agricultural Economics in 1926 published a bibliography on factors of prices (99—14), and in 1933 a bibliography of price analysis (99—48).

Another study conducted in coöperation with the State agricultural colleges since 1928 covers records of regional farm prices. These are needed in connection with the preparation of the annual outlook reports. The coöperation begun with the Colorado and Oregon colleges in 1928, required redistricting of the States into economic instead of strictly geographic areas (98—1928:9), and has since been established in other States. Some of those studies are the products of coöperation only with the Federal Division of Crop and Livestock Estimates. One such was concerned with production, prices, and destinations of potatoes in South Dakota (70—234), published in 1928. The Utah Station published a similar

coöperative study of prices of farm products (123—217) in 1930.

In order to make this study of farm prices more effective in determining farm-crop values, coöperation was arranged with the Bureau of the Census in 1929. Technical and clerical assistance was furnished by that Bureau to permit obtaining farm prices by counties on many agricultural commodities covered by the census of 1930.

MISCELLANEOUS STATISTICAL DATA

Among the miscellaneous statistical data are those covering freight rates, farm incomes, and sources of statistical matter. Other statistical compilations will be discussed under the section of this chapter which covers marketing.

Freight Rate Data

In 1914, the Bureau of Crop Estimates and Office of Markets of the U. S. Department of Agriculture published a joint contribution covering freight rates on farm products on inland waterways of the United States, acknowledging minor assistance received from the Engineer Corps of the U. S. Army (86—74).

The Bureau of Agricultural Economics, U. S. Department of Agriculture, has prepared much material in this field for the use of the Interstate Commerce Commission in deciding freight-rate cases. This service was begun with index numbers on freight rates for wheat in 1926, and has been continued since on livestock, cotton, and other products.

Farm Incomes

Statistical estimates of gross farm income have been made for many years and entail coöperation between several Divisions of the Federal Bureau of Agricultural Economics.

Bibliographies of Statistical Source Material

Compilations of the official sources of statistical material within individual States are highly important to both State and Federal workers. At the annual meeting of the American Library Association in 1925, it was proposed that the library of the U. S. Department of Agriculture coöperate with the libraries of the State agri-

cultural colleges in preparing such compilations. Three such have since been published in the series of mimeographed bibliographies issued by the Federal Bureau of Agricultural Economics under the title, *Agricultural Economics Bibliography* (99). The first covered official sources for such statistical matter in Alabama (99—15) and was issued in 1926 without any statement of actual co-operation. In the same year, coöperation was arranged with the Oklahoma Agricultural College, through which an assistant librarian from that institution was assigned for two months to the library of the Federal Bureau of Agricultural Economics, and a similar bibliography of Oklahoma official sources (99—21) was published in 1927.

A coöperative arrangement was made with the California Agricultural Experiment Station in 1927 by which that station paid the salary of a worker in the Federal Library to compile official sources of California statistics. These were issued in 1930 and 1931 (99—31) in five parts, comprising more than 1500 mimeographed pages. The first four parts dealt with fruits, vegetables, and nuts; crops other than the above; livestock and their products; land, farms, irrigation, etc.; and unofficial sources for California material, the latter compiled by the agricultural reference librarian at the University of California College of Agriculture.

The publications listed in the Literature Cited at the end of this chapter which have been cited in these sections on Introduction and on Crop and Livestock Statistics and Estimates are Nos. 5, 24, 26, 31, 34, 35, 38, 43, 47, 54, 55, 57, 61, 68, 69, 70, 86, 87, 88, 89, 92, 94, 96, 98, 99, 101, 102, 107, 112, 114, 115, 116, 117, 118, 123, 126, and 127.

3. FARM MANAGEMENT AND COSTS

FARM MANAGEMENT STUDIES, Federal and State, have been in progress since 1902. Their historical development is presented briefly and then the coöperative activities are discussed.

HISTORICAL DEVELOPMENT

Here is presented a birds-eye view of the Federal and State agencies involved, of the scope and extent of the coöperative studies made and the results published.

Federal and State Agencies

In 1902, the United States Secretary of Agriculture (85—1902: 15—16) gave permission to the Bureau of Plant Industry to establish an Office of Farm Management. The purpose was to study systems of management obtaining on the best-managed farms, and to assemble and apply scientific facts. The Minnesota Station began similar studies in the same year. The Federal farm management studies were put in charge of the Chief of the Office of Grass and Forage Investigations. In 1904, a Committee on Farm Management Studies, consisting of the chiefs of five interested Divisions, was created within the Federal Bureau. Under an Act of June 30, 1906 (34 U. S. Stats. L, 669, 680), the Bureau of Plant Industry was specifically authorized "to investigate and encourage the adoption of improved methods of farm management and farm practice."

In the departmental reorganization of July 1, 1915, the Office of Farm Management was made an independent Office, directly under the Secretary of Agriculture. In 1919, the name was changed to the Office of Farm Management and Farm Economics and it was made independent. On July 1, 1922, it was combined with the Bureau of Markets and Crop Estimates to form the Bureau of Agricultural Economics. At first two separate Divisions, Farm Management, and Costs of Production, respectively, were maintained, but in fiscal year 1925 these were combined into a single Division of Farm Management and Costs, which continues.

In 1922, this Office, in its final Annual Report, published a brief history of the Office, an organization chart, a list of the principal achievements with citation of publications, and finally, a list of the publications of the Office from its creation in the Bureau of Plant Industry in 1902 to the end of the fiscal year 1920, arranged by the different series of Bureau and Departmental publications (104—1922:545—66).

In various special surveys, the above-named Division had the coöperation of the Divisions of Crop and Livestock Estimates, and Statistical and Historical Research. In some of the studies of individual crops or classes of livestock, help was had from the various commodity Divisions of the Federal Bureau, i.e. Fruits and Vegetables, Dairy and Poultry Products, etc. Studies in their respec-

tive fields were aided by the Bureaus of Animal Industry and Plant Industry, the Forest Service, the Division (and Bureau) of Agricultural Engineering, and the Weather Bureau. In a few studies the United States Tariff Commission was an investigating agency.

A Department of Farm Management was created in the College of Agriculture of the University of Minnesota in 1902, the year in which Federal farm management studies were begun in the Bureau of Plant Industry. The development of such departments of agricultural economics in other colleges of agriculture went forward rapidly thereafter. At the beginning, their studies of farm management practices were conducted independently of other official agencies. As they progressed to the more specialized studies of various plant or livestock industries, coöperation began with other departments of their own institutions. Such other departments were agronomy (crops and/or soils), horticulture (and/or pomology), animal husbandry, dairy husbandry (where separate from the preceding), agricultural engineering (farm mechanics or rural engineering), and forestry.

The development of divisions of agricultural economics or of farm management in the State agricultural experiment stations proceeded more slowly, but their scope was greatly enlarged after 1925 by the Federal funds from the Purnell Act.

Coöperation developed later between the State agricultural colleges and experiment stations on the one side and the State departments of agriculture or equivalent State agencies on the other. Gradually, also, there was built up some coöperation with the Federal Office of Farm Management, as will be noted under Publication of Results and in the discussion of coöperative enterprises which follows.

Lines of Work

The first activities undertaken were studies of farm management practices on outstandingly successful farms, or on groups of farms in prosperous communities. Between 1902 and 1915, inclusive, while the Federal Office of Farm Management was in the Bureau of Plant Industry, it studied farm practices on such subjects as forage growing in the South, haymaking, corn cultivation, weed control, soiling and silage use, tillage methods, seed improvement, manures and fertilizers, dairying, range management, and similar

subjects. Later, farm equipment and structures, farm tenancy, and agricultural geography were included, and the name changed to Office of Farm Management and Farm Economics.

In 1904, the planning of cropping systems suitable for farms in different areas was begun, and plans for laying out farms were made for applicants. This was accompanied by the establishment of privately owned but Federally supervised diversification farms in the South and demonstration farms in the northern States. This activity followed the establishment of demonstration farms in the coastal portion of the cotton belt by another Office of the Bureau of Plant Industry, to show farmers the methods of boll-weevil control.

As early as 1906, the Office began determining the cost of production of farm commodities. Some of these studies were concerned with the cost of producing a single item, such as wheat or milk. Others covered complete cost-accounting systems for all farm operations. The study of the records obtained in this latter activity became the basis for complete analyses of the farm business.

Most of the early studies were conducted independently of State agencies. Gradually, however, coöperative relations developed and, by 1915, when the Office of Farm Management was transferred from the Bureau of Plant Industry, many studies were coöperatively made. The percentage steadily increased.

By 1923, soon after the Office had been merged with the newly created Bureau of Agricultural Economics, the Division of Costs of Production reported that all its studies of cost accounting were conducted with the collaboration and financial assistance of the State colleges of agriculture and experiment stations (98—1923: 141). The records covered production of wheat in Idaho, Kansas, Oregon, and Washington, corn in Illinois, cotton in South Carolina, sugar in Louisiana, tobacco in Kentucky and Virginia, apples in Virginia, and peaches in New Jersey (98—1923: 143). By 1925, the number of coöperating States had increased to fifteen. By 1932, the number of joint projects on cost analysis had risen to about fifty.

By 1923, the Division of Farm Management and Costs, in collaboration with other Divisions of the Federal Bureau of Agricultural Economics, and with numerous State agricultural colleges and

experiment stations, had begun extensive studies of farms located near cities, with a view to assisting in the readjustment of their production programs. This work then was being conducted in Georgia, Indiana, New Jersey, North Carolina, Virginia, and West Virginia.

Farm management studies, based on analysis of farm records and accounts, constituted an important part of the work of the Office and subsequent Division of Farm Management. It acted also as a coördinating agency in assembling and compiling the results of such studies, whether coöperative or independent in origin. These showed the type of farming, acreage, capital, expenses, and various forms of income, including the family living obtained from the farm. Forms for obtaining necessary daily records were supplied by the Division on request. Results of such studies are presented in many of the publications discussed in later subsections of this section. A summary of the distribution of types of farming in the United States, published (87—1289) by the Division in 1925, contained results of both independent and coöperative studies.

In 1925 also, the results of analysis of business records of 71,500 farms in 435 separate localities in 45 States were summarized by the Federal Division for publication in the *Yearbook of the United States Department of Agriculture* (96—1925:1285—1311). In 1931, an additional 30,000 farm records, obtained from 336 separate localities in 25 States, were published in the *Yearbook* (96—1931: 984—1012).

By 1927, the making of farm budgets, based on the farm accounts of the previous year, was worked out in coöperation with several State colleges of agriculture, including North Carolina, Kentucky, Minnesota, and North Dakota.

Publication of Results

From 1906 onward, the Office of Farm Management published extensively on farm practices, conditions, cropping systems, operating costs, incomes, and so forth. From 1906 to 1913, many of these studies were published in the *Bulletin* and *Circular* series of the Bureau of Plant Industry. Some represented coöperation with other agencies and institutions (110—94, 236, 239, and 259; 111—

60, 75 and 128 A). Quite as many were wholly independent in origin. Between 1906 and 1920, the Office also published some forty *Farmers' Bulletins* dealing with phases of farm management. Of these, only four (87—294, 310, 572, and 1047) were stated to be the results of coöperative activities. In 1913, the series of *Department Bulletins* was started and 1500 numbers issued to 1927, when it was discontinued. The Federal Farm Management unit contributed 118 of this total number, of which 58, or 49 per cent, were coöperative. From 1913 to 1920, however, about 40 per cent were coöperative and from 1921 to 1927 about 60 per cent. About half of the 118 bulletins appeared in each of these seven-year periods.

GENERAL FARM MANAGEMENT

In this subsection are presented only those studies which cover the general farm enterprise. More limited studies are presented under Farm Crop Management, Livestock Management, and Farm Power and Machinery Management.

There is not always a clear distinction between the special crop and livestock surveys discussed in the preceding section on Crop and Livestock Estimates and Statistics, the farm-management and cost-of-production surveys of individual industries discussed in this section, and some of the marketing surveys presented later in the section on Marketing. The placement has been determined by the major emphasis and the principal Federal coöperating agency.

Farm Management Extension

The Office of Farm Management established diversification farms in the cotton belt and demonstration farms in the northern States to illustrate approved farm management practices. The plan to establish one such farm in each congressional district was carried forward vigorously in 1904 and 1905, extending to New England in the latter year. Staffs of the agricultural colleges and experiment stations in the South assisted greatly in selecting the farms, in planning the cropping systems, and in supervising the work. All records kept on these farms were copied in duplicate by the Federal agency, one set of records being furnished to the agricultural experiment station of the State concerned. The area was organized

into five supervisory districts, with a Federal agent in charge of each. In 1907, the Office and the Alabama Agricultural Experiment Station jointly authored a publication (87—310) on a successful Alabama diversification farm, one of several maintained coöperatively by the two agencies.

Beginning in 1913, farm demonstrations were undertaken on a large scale in the northern States, under an appropriation of \$160,000 for this purpose. By 1914, this work had greatly enlarged. These demonstration farms actually were more nearly agricultural-extension than farm-management studies. With the reorganization in 1915, this phase of the work was transferred to the newly created States Relations Service as an agricultural extension activity. However, the Office still coöperated extensively with the States Relations Service.

In January, 1917, the Office of Farm Management entered into an agreement with the Federal Office of Extension Work, South, and subsequently into practically identical agreements with the extension divisions of several State colleges of agriculture in the southern States for coöperative extension and also investigations in farm management. Such agreements were made in six States in that year, and were ready for operation in five others when finances should permit. The object was to assist State extension divisions and the county agricultural agents, first in ascertaining the relative importance of the principal factors of profits and of losses, and, second, to demonstrate practical methods of analyzing the farm business in order to measure profits and decide what readjustment should be made in the enterprise. Farm account books for recording the farm business were issued in enormous numbers in the southern States, partly through financing by bankers.

By 1920, a more equitable division of the expenses between the Federal Office and the State Extension Divisions was under discussion. Adjustments were made in Alabama and Georgia on a fifty-fifty basis, and were under consideration in other States. Arkansas and Mississippi established Departments of Farm Management and Farm Economics on a coöperative basis. These financial arrangements were continued to about the year 1922, when the appropriation of funds to investigating units for extension work was discontinued by the Federal Congress.

Farm Management Methods

In 1912, the Office published a comprehensive discussion of the organizing of research and teaching in farm management (110—236). The four authors were members of the staff of the College of Agriculture of the University of Minnesota. The words "In coöperation with the Minnesota Agricultural Experiment Station" appear on the cover. Apparently, however, the coöperation consisted in the preparation of the manuscript by the station and its publication by the Federal Department. It was published also by the Minnesota Station (40—125) in identical form with the Federal publication.

In 1912, the Office published a comprehensive bulletin (110—259) under the title, *What Is Farm Management?* The second part of this bulletin, called "The Work of the Office of Farm Management" (pp. 39—84), discusses the various activities on which the Office was then or had been engaged. Farm cost-accounting records were kept in coöperation with the Missouri, Ohio, and Wisconsin Stations. In those States, all such farm records were received and tabulated by the stations, and copies furnished to the Office (p. 40). In coöperation with the New York (Cornell) Station, the Office employed a man to help farmers develop systems of bookkeeping for their own use, including cost-accounting records (p. 41). This resulted in 1914 in a Federal publication (87—572) on a system of farm accounting, prepared by a Cornell University staff member. A footnote said that the system, devised at Cornell, had been thoroughly tested on numerous farms during three years while the author was working jointly for the Federal and State agencies. In 1921, the Federal Office of Farm Management and Farm Economics published a summary of methods of conducting cost-of-production and farm-organization studies, for the information of all coöperating agencies (86—994).

Farm Management Studies

In about 1915, the Federal Office of Farm Management made a study of the economics of the farm wood lot in the eastern and southeastern States, in coöperation with the Forest Service (103—1916:417). Beginning about 1926, detailed analyses of types of

farming were undertaken by the Federal Division of Farm Management and Costs, in coöperation with the agricultural experiment stations of nine different States. By 1930, it was reported that these analyses had been completed in Kansas, Michigan, Minnesota, Nebraska, North Dakota, Oklahoma, South Dakota, and Texas. They furnished a basis for determining farm management programs and interpreting the annual outlook reports discussed in the preceding section of this chapter.

In about 1929, the Federal Division of Farm Management and Costs began a coöperative study of the organization, operation, and management of large-sized farms throughout the country. This was conducted through the use of 22,000 questionnaires, mailed to persons whose names had been provided by the crop reporters of the Federal-State Crop Reporting Service and by bankers (98—1930: 8). Later, this study was continued, in coöperation with the Federal Bureau of the Census, on 7875 large-scale farms, of which 25% were fruit farms, and 23% were stock ranches. Three other types, dairy, truck, and special crops farms, made up another 30% of the total, grain and cotton farms being relatively unimportant.

The Federal Bureau of Agricultural Economics has issued two bibliographies concerned with farm management, the first on large-scale and corporation farming (99—30), published in 1929, the second on group and chain farming (99—46), published in 1933.

For convenience of the reader, the presentation is by five geographic areas—the northeastern States, the southern States, the north central States, the Great Plains, and the far western States.

In the northeastern States.—This group includes the New England States, New York, New Jersey, and Pennsylvania. Because farming is relatively specialized in this area, only a few general farm-management studies have been made by the Federal Office in coöperation with State agricultural experiment stations.

In New Hampshire, two coöperative studies of limited scope were made from 1909 onward and both published (111—75; 128A) by the Federal agency in 1911 and 1913. The first publication carried prominent cover and text statements of coöperation. In Connecticut, a coöperative study of farming types in the eastern highlands was published by the Storrs Station (12—191) in 1933, with a cover statement of coöperation.

The New York (Cornell) Agricultural Experiment Station began, in 1912, a coöperative six-year study of cost accounting on successful New York farms, in collaboration with the Federal Office of Farm Management. The results were published by the Cornell Station (57—414) in 1923, with a cover statement of coöperation.

In Pennsylvania, several coöperative farm management studies were made, each usually concerned with a single county. In Chester County, the Pennsylvania State College merely assisted in the Federal study, published in 1916 by the Federal agency (86—341). A re-study was begun in 1923. A similar study in northwestern Pennsylvania, published by the Federal Office (86—853) in 1920, acknowledged assistance from the Pennsylvania Station and the Federal Dairy Division.

From 1923 to 1928, the Pennsylvania Station and the Federal Office conducted coöperative studies of farm management and land utilization in Blair (66—184), Lebanon (66—198), Wyoming (66—257), and Tioga (66—282) Counties, and the results were published by the State agency. Other coöperating agencies in one or another of these studies included the Federal Bureau of Soils, the Pennsylvania State Department of Agriculture, the Pennsylvania State College Extension Service, the Station Departments of Agronomy and Forestry, and various county agricultural agents. In 1934, the Pennsylvania Station published a general study of farming in that State (66—305) under joint authorship with the Federal Division of Farm Management and Costs.

In the southern States.—Farm management studies coöperative between the Federal Division of Farm Management and Costs and the State colleges of agriculture have been made in virtually every one of the southern States. These studies were greatly expanded after the World War, when the slump in cotton prices made farm readjustments imperative. Many studies, especially of farm-crop and livestock enterprises, are presented later under those headings.

The Federal Division, in 1930, aided the U. S. Department of Justice on problems of organization and operation of Federal prison farms, especially the 1200-acre penitentiary farm near Atlanta and the 2500-acre Federal Road Camp near Petersburg, Virginia. Assistance was given also by the Bureaus of Animal In-

dustry, Dairy Industry, Chemistry and Soils, Plant Industry, and Public Roads of the U. S. Department of Agriculture on numerous items, while dietary studies and recommendations were made by the Federal Bureau of Home Economics (98—1930:14).

In 1929, the Federal Division of Farm Management and Costs recorded that it was making a study of profitable farm systems under the broken topography of the Appalachian plateau of Kentucky, North Carolina, and Tennessee, in coöperation with the experiment stations of those States.

In Virginia, two combined farm management and marketing studies, one in the Roanoke (125—240) and the other in the Clifton Forge—Covington (125—266) area, have been coöperatively made and published under joint authorship by the Virginia Station. These represented coöperation with the Virginia Polytechnic Institute and assistance from Federal Crop and Livestock statisticians in Virginia, the Virginia Water Power and Development Commission, county agricultural agents, and commercial agencies.

In West Virginia, in 1915, an agricultural survey of Brooke County was made by the State Station and the Federal Office and jointly authored (130—152). In 1914, the two agencies began a survey of Greenbriar and Monroe Counties (130—173), published in 1920. Two studies on adjusting agricultural production and distribution to meet home-market demands in south central West Virginia (130—188) and the Wheeling area (130—228), were conducted coöperatively in 1923 and 1926, respectively, the first being under joint authorship.

In North Carolina, the Federal Office and the State Station co-operated in a jointly authored study in Catawba County, published (86—1070) in 1922. During 1925 and 1926, the two agencies made a study of profitable farm combinations (58—252), and in 1931 they published a discussion of planning the farm business (58—277).

The South Carolina Station, in coöperation with the Federal Office and Division, studied farming for profits (69—230), which covered five years during the period from 1914 to 1925. In 1926 and 1927, the same agencies coöperated in an economic study, jointly authored, of the Columbia area (69—243) and an agricultural survey of the Charleston area (69—253). The second

acknowledged specific information from the Federal Census, Soils, and Weather Bureaus, the Post Office at Charleston, and the Charleston Bureau of Port Development and Department of Health.

In Kentucky, several studies of farm organization, farm management, and farm income were made in coöperation with the Department of Farm Economics of the Kentucky Station and published by the Station between 1924 and 1934. These cover Mason and Fleming Counties (32—253), Union and Henderson Counties (32—261), the Purchase Area (32—289 and 292), Laurel County (32—305), Grayson County (32—317), and Todd, Christian, and Warren Counties (32—347). In the earlier studies, the Extension Division and county agents coöperated, and in the Laurel County study the Federal Divisions of Land Economics and Farm Population and Rural Life assisted. In 1930, a coöperative study was begun of the management of farms of unusual size.

In coöperation with the Tennessee Station, the Federal Division began farm-account surveys in Overton and Washington Counties in 1927 and summarized and interpreted those from some two hundred farms in 1930.

From 1914 onward, the Georgia State College of Agriculture coöperated in farm management surveys in Brooke (86—648) and Sumter (86—1034) Counties, the results being published by the Federal agency in 1918 and 1922.

In Mississippi, the State Station and the Federal Division coöperated from 1924 onward in costs of production studies and the formulation of systems of farming which were published under joint authorship by the Station. These included Choctaw County (42—228, 237, 243, and 257) in the hill section, and Jones County (42—256, 269, and 276) in the south central portion. A comprehensive study of agricultural opportunities in southern Mississippi (43—1) resulted from coöperation of the Federal Bureau, State extension agencies, the city of New Orleans, and commercial organizations.

The Louisiana and Mississippi Colleges of Agriculture detailed research and extension specialists in marketing and production to work with the Federal Division in a study of farms near cities in Louisiana and the southern half of Mississippi in 1925 and 1926.

In Arkansas, records of farm accounts were maintained coöperatively upon more than two hundred farms, and a preliminary report published in about 1926. A study of farm organization in the low hills of southwestern Arkansas was nearly completed in 1929 in coöperation with the State University.

The Oklahoma Station and the Federal Division made a comprehensive study of types of farming (62—181) and a similar study of farming systems for wheat production in north central Oklahoma (62—199). These were published under joint authorship in 1929 and 1931. The first acknowledged statistical help from the State statistician of Oklahoma and the Federal Bureau of the Census. Farm costs of production for 1931, studied by the Oklahoma Extension Service with Federal coöperation, were published by the Station (62—208) in 1933.

At the request of the Texas Agricultural College, the Federal Division of Farm Management and Costs, in 1924, assisted in a study of the organization and operation of fourteen Texas prison farms, which resulted in numerous recommendations looking toward self-support.

From 1921 to 1929, the Division of Farm and Ranch Economics of the Texas Station coöperated with the Federal Division in studies of systems of farming for the black waxy prairie belt, published by the Station (73—395), for Texas as a whole (73—427), and for the piny woods (73—453). These were published under joint authorship from 1929 to 1932.

In the North Central States.—From about 1912 to 1919, the Federal Office of Farm Management made a series of studies on farm profits (86—920) in Washington County, Ohio (86—716); Clinton County, Indiana (86—1258); and Dane County, Wisconsin, in coöperation with the Agricultural Experiment Stations of those States. The data were obtained from the same farms through the series of years and were published by the Federal Office. In 1919, the Federal Office began active coöperative studies of farm management with the Agricultural Experiment Stations in four States of this area, Illinois, Indiana, Iowa, and Missouri, as well as in Nebraska. In most cases, these included complete business analyses of the farm records taken.

The Illinois Station in 1924 published a study of the increased

farm earnings resulting from the use of simple farm accounts (26—252), with coöperation of the Extension Service and various county farm advisors acknowledged. In 1934, Federal-State coöperation resulted in a comprehensive bulletin on types of farming in Illinois (26—403), written jointly, and with the coöperation prominently displayed on the cover page.

In Indiana, an early coöperative study was mentioned in the general discussion. Federal-State coöperation in a study of the organization of farms of different sizes, begun about 1923, covered 80-acre farms (87—1421), 160-acre farms (87—1463), and 240-acre farms. Later Federal-State coöperation covered changes in agriculture in northwestern Indiana (28—321) and types of farming for the State (28—342), published in 1928 and 1930, with prominent cover-page statements of coöperation. Still later studies of the human element in farm management (28—369) and of the adjusting of farming to corn-borer conditions (28—389) were issued in 1932 and 1934 under joint authorship.

An early coöperative study in Ohio is mentioned above in the general discussion. The Federal Division coöperated with Ohio State University in a study of farm management and organization in the hill sections of southeastern Ohio, from about 1923 to 1927, or later, and at least one publication was issued.

In Michigan the Station and the Federal Division made a coöperative survey of types of farming, published (37—206) in 1930, under joint authorship, and with a prominent cover display of the coöperation.

In Wisconsin, the State Station published, in 1919, two coöperative studies based on war activities in Wisconsin agriculture. The first covered a coöperation by the Station and the Federal Office of Farm Management (133—300), in the period from 1914 to 1917. The second was an account of war activities of the Federal-State Agricultural Extension Service (133—301), and also included coöperation of the Wisconsin State Department of Agriculture and the State Horticultural Society. Coöperative taking of cost records was begun by the Federal Office and the Wisconsin Station about 1916 (see 87—511, 572, 661, and 782). From 1924 to 1928, the State Station, the Federal Division, and the State Department of Markets studied why some farms pay (133—364), planning the

farm for profits (133—395), and costs and practices in Walworth County (134—83), published with cover statements of coöperation.

In Minnesota, coöperative activities in farm management began soon after the organization of the Federal and State units in 1902, and Minnesota data were included in numerous early publications of the Federal agency. From about 1914 onward, cost-accounting records were taken coöperatively. From 1920 to 1922, such studies were made in Cottonwood and Jackson Counties and published later by the State Station (40—205) and the Federal agency (86—1271), under joint authorship, with cover and text statements of coöperation. Coöperative studies of systems of farming in northwestern Minnesota (40—268), in the Red River Valley (40—284), and in the cutover section of northeastern Minnesota (40—295), were published by the Station from 1930 to 1933, under joint authorship, with cover statements of coöperation. A Station study of systems of farming in eastern and southern Minnesota (40—276), published in 1931, acknowledged coöperation from the Federal Bureau of the Census in making tabulations of data in 1925.

The Iowa Station in 1914, made a farm management survey in Blackhawk, Grundy, and Tama Counties. This was repeated with Federal coöperation in 1918 and the results published (29—198) in 1921. A similar State survey was made in Warren County in 1916, and coöperative surveys (29—229) repeated in 1919 and 1922. Similar coöperative surveys in Tama County (30—88) were made in 1918 and 1921 and compared with a State survey of 1913.

In the Great Plains.—Beginning in about 1921, the Federal Division of Farm Management and Costs began coöperation with the State agricultural experiment stations in an extensive study of costs of production and of farm organization in the Great Plains. By 1923 the Federal Division of Land Economics had joined in the coöperation, and land utilization was included in some of the studies.

In North Dakota, the investigations began in 1921 and were published by the State Station at intervals thereafter. They included a general study (60—165), the southwestern section (60—180) under joint authorship, later changes therein (60—201), and the thirteen agricultural areas of the State (60—212), also under joint authorship in 1927. The latter included an analysis of farm

statistics from the Federal Bureau of the Census and Division of Crop and Livestock Estimates, and was published also by the Federal agency (86—102), with cover and text statements of coöperation. Later studies, begun in 1930 in east-central North Dakota, were published (60—273) under joint authorship in 1933.

In South Dakota, coöperative studies begun in 1922 covered east-central South Dakota (70—226), a State-wide study (70—238), and the southeastern section (70—249), all published between 1927 and 1930, and the first under joint authorship.

In Montana, a coöperative statistical study of the dry-land area (47—185) was issued in 1926, and in 1933 one on farm organization as affected by mechanization (47—278). A study in southeastern Montana (47—287) involved only the Station and Extension Divisions.

In Nebraska, a jointly prepared State-wide study of farming types was issued (50—244) in 1930. In Colorado, a coöperative study of profit factors on irrigated farms, begun in 1922, was published (11—218) in 1927.

In Kansas, a three-year coöperative study in the central portion, begun in 1921, appeared under joint authorship (86—1296) in 1925, and a State-wide study, also under joint authorship (31—251) in 1930, with assistance acknowledged from the Federal Bureau of the Census and Division of Crop and Livestock Estimates.

In the Pacific Northwest.—One of the earliest coöperative Federal-State studies covered farm practices in the Columbia Basin Uplands of Oregon and Washington (87—294), published in 1907. In the Letter of Transmittal, it was stated that "this Bulletin is to be issued jointly by the U. S. Department of Agriculture and the Oregon and Washington Agricultural Experiment Stations," but apparently the States did not publish their editions. In 1910, the Office of Farm Management published suggestions to settlers in the Columbia Basin of Oregon and Washington (111—60), based on coöperation with the Section of Irrigation Investigations of the U. S. Office of Experiment Stations.

In Idaho, the Federal-State agencies began coöperation on studies, in 1919, of farm organization in Twin Falls and Latah Counties (24—123), costs and profits of seven crops in Twin Falls County (25—2), and a business analysis of some two hundred

farms in the same county (24—132), the latter with assistance from the Federal Office of Sugar-Plant Investigations. Later studies in the Twin Falls Irrigation Project (24—195) and in the Idaho Falls area (24—198) were published in 1932 and 1933, with cover statements of coöperation, and the first under joint authorship. Two jointly written coöperative bulletins, published in 1934, discussed agricultural resources (24—207 and 208) and type-of-farming areas.

In Washington, results of coöperative studies of farming logged-off uplands (86—1236) and irrigated farms of the Yakima Valley (86—1388) were published by the Federal agency in 1924 and 1926. The latter, under joint authorship, included coöperation from the Federal Bureaus of Plant Industry, Reclamation, and Indian Affairs, and county agricultural agents. A jointly presented coöperative study of Big Bend agriculture (128—192) included results from coöperative branch stations in Oregon and Washington and the assistance of the Washington Extension Division. A jointly authored discussion of present land uses of Washington (128—288), with a cover statement of coöperation, acknowledged assistance from the Forest Service and the Pacific Northwest Federal-State Soil Erosion Experiment Station.

In Utah, coöperation in farm-management studies was begun in 1914 on important factors in the operation of irrigated farms (123—160). More detailed data relating to the Provo area were published by the Federal agency (86—582) in 1918, with coöperation also by officials of the Federal Forest and Reclamation Services acknowledged. A farm management study of the Great Salt Lake Valley, made in 1915, was published (123—184) in 1923, with assistance from the Federal Office of Sugar-Plant Investigations acknowledged. In 1929, coöperation was renewed in a study of farm reorganization in Cache County and the results published by the State for extension use.

In Nevada, the economic history of the Newlands Irrigation Project was published by the Station (53—120) in 1930, based on census data taken by the Reclamation Service of the U. S. Department of the Interior from 1912 to 1929. Two later bulletins (53—123 and 127) contained similar data for the years 1930 and 1931.

In New Mexico, the Experiment Station published, in 1930 and

1931, three jointly written coöperative bulletins (56—186, 187, and 188) on the economics of dry-land farms in eastern New Mexico, with assistance acknowledged from other Federal Divisions and the Extension Service, including county agents, of New Mexico. In 1933, the Station (56—215), in a study of the Central Rio Grande irrigation area, acknowledged data from the appraisal engineer of the Middle Rio Grande Conservancy District and the county agricultural agents of three counties.

The Arizona Station and the Federal Division coöperated in studies of farm reorganization in the Salt River Valley, and a detailed manuscript was prepared in about 1929. In California, the two agencies made a study of farming systems in the San Joaquin Valley in 1928.

FARM CROP MANAGEMENT

The general farm management studies, discussed in the preceding section, covered both crop and livestock enterprises. A much larger number of coöperative studies were concerned with individual kinds of crops or classes of livestock. It is impossible to discuss these separate studies, because of space limitations. In general they show the same major Federal and State agencies and the same coöperative procedure and publication.

One principal difference between the special crop studies and the general studies lies in the number of minor coöperating or assisting agencies. In many of the special crop studies, the Federal and/or State station division charged with responsibility for that crop coöperated with the Federal and State farm management divisions in the investigation of it.

Field-Crop Management

A few coöperative farm management studies published by the State stations have been concerned with field crops in general. Among them are production costs on irrigated farms in Weld County, Colorado (11—353), cropping systems in Iowa County, Iowa (29—261), crop-production practices in Michigan (38—241), crop production in Red River Valley of Minnesota (40—282), cost of crop production in North Dakota (60—199), crop production costs in Green County, Ohio, and emergency crop adjustments in South Dakota (71—8).

Crop labor requirements and costs.—A few studies have been concerned with the farm-labor aspects of crop production. Beginning in 1913, the Federal Office of Farm Management coöperated with various State stations in determining the amount and cost of labor required for growing crops. From 1917 to 1919, during the World War and the period of demobilization, there was widespread coöperation between numerous Federal and State agencies, including the Federal Office of Farm Management, in maintaining adequate supplies of farm labor and in assisting demobilized soldiers and sailors to find farm employment.

Among the prewar coöperative studies of labor costs in crop production was one conducted in West Virginia (130—163) from 1913 to 1915, and another made in Utah in 1915 on irrigated crops in the Utah Valley (123—165).

From 1920 to 1922, the Federal Office of Farm Management and Farm Economics studied harvest-labor problems in the wheat belt from Oklahoma to the Dakotas, Iowa, and Minnesota (86—1020), with some assistance from county agricultural agents, State employment officials, business men, and farmers. Later studies of State labor requirements, with minor coöperation from the State agricultural colleges, were published by the Federal Department for Arkansas (86—1181) and Massachusetts (86—1220) in 1924. The study of sources of supply and conditions of employment (86—1211) and an extensive investigation of the actual demand for harvest labor and the development of a formula by which such demand could be expressed in terms of the average number of men required (86—1230), both published in 1924, were made independently by Federal men, but acknowledged assistance from Federal, State, and county agricultural and employment officials.

From 1923 onward, labor studies were conducted by the Division of Farm Population and Rural Life. A bibliography on labor requirements of farm products was published (99—26) in 1929.

Special field-crop studies.—For convenience, field crops are separated into cereals, forages, fiber crops, sugar crops, and tobacco. The grouping is somewhat inconsistent in that sugar beets are classed as a field crop along with sugar cane, while potatoes are placed under truck crops with other vegetables.

Some eighty-four farm management coöperative studies of crops

in one or another of these five groups have been noted. It is possible to discuss only a few cases which show special features of coöperative activity or publication.

The general farm management studies already discussed necessarily include some or all of the cereal crops, wheat, oat, barley, maize, rye, rice, grain sorghums, and seed flax, as grown throughout the country. Only a single special study will be noted. In 1929, a study of farm organization in wheat areas of northern Idaho and eastern Washington was made in coöperation with the Farm Management Divisions of the Experiment Stations of those States. The results were published by both States (24—173; 128—244) in 1930 under joint authorship of the three agencies. Each bulletin declares on the cover that it also is the designated bulletin of the other State, and evidently both were printed from the same setting of type. A footnote acknowledges the coöperation also of the Experiment Station Departments of Agronomy, Agricultural Engineering, Animal Husbandry, Dairying, and Poultry Husbandry in both States.

A bibliography of papers on the cost of producing wheat, covering publications issued from 1923 to 1930, inclusive, was issued by the Federal Bureau of Agricultural Economics (99—33) in 1931.

A study of farm practices with forage crops in the western part of Oregon and Washington (110—94), made in coöperation with the Experiment Stations of those States, was published by the Federal Office in 1906. This publication was unique in that it was agreed that the same data should be published by the States also, as stated in the Letter of Transmittal. The Oregon Station published its bulletin (63—91). On the cover are the words, "Published jointly by the U. S. Department of Agriculture and the Oregon Agricultural Experiment Station." The text of the two publications is identical, but the type was set independently.

In 1929, the Division of Farm Management and Costs, in coöperation with the Division of Cereal Crops and Diseases of the Federal Bureau of Plant Industry, and the Agricultural Experiment Stations of Illinois, Kansas, and Oklahoma, began an economic study of broomcorn production. The results were published in popular form (87—1631) in 1930, and in technical form (89—

347) in 1933, the latter under joint authorship of the two Federal Divisions, with the coöperation of the Illinois and Kansas Stations acknowledged.

Because of the special nature of sugar crops, the Office of Sugar Plant Investigations in the Bureau of Plant Industry has coöperated with the Office of Farm Management in a large proportion of the studies of this group of crops. From 1914 to 1919, the coöperative agreement resulted in joint authorship of studies in eight States from Ohio to California. (86—693, 726, 735, 748, 760, 917, and 963). The Montana studies were published by the State Station (47—129 and 144), and also were under joint authorship. A later coöperative publication of the two Federal Divisions and the Idaho Station also was jointly prepared (86—1421).

In 1925, the United States Tariff Commission and the Vermont Agricultural Experiment Station made a coöperative study of the economics of the farm manufacture of maple syrup and sugar in that State. The Vermont Station published the results in a series of three bulletins (124—285, 286, and 292) issued in 1928 and 1929, and showing the coöperation on cover and in text.

Fruit and Nut Crop Management

While there are many fruit and nut crops, relatively few are of sufficient area and distribution to constitute major farm-management problems. Only apples, pears, peaches, citrus fruits, and strawberries have been treated separately in coöperative farm-management and cost-of-production research.

Two recent studies have been concerned with both fruits and vegetables. One was made in New Jersey (55—555) with Federal coöperation. Another by the Utah Station (123—214), conducted in Washington County, southwestern Utah, included the contiguous Moapa Valley in southeastern Nevada, and the aid of the Nevada Agricultural Extension Service was obtained in the survey of that portion.

Between 1910 and 1915, the Office of Farm Management and the Office of Horticultural and Pomological Investigations, both in the Bureau of Plant Industry, collaborated in extensive studies of the cost of producing apples in different parts of the United States. The results of six such studies were published between 1917 and

1920. The areas covered were the Wenatchee and Yakima Valleys of Washington (86—446 and 614), western Colorado (86—500), the Hood River Valley in Oregon (86—518), the Payette Valley in Idaho (86—636), and five counties in western New York (86—851).

Special nation-wide horticultural and statistical surveys of the number of trees, variety percentages, and trends of production, of apples, pears, and peaches, were conducted by the Federal Bureaus of Crop Estimates and Plant Industry at the same time that these cost-of-production studies were made. The coöperative results (86—485, 806, and 822) were discussed in section 2, under Special Surveys.

Some ten years later, in 1926, the Federal Divisions of Farm Management and Costs, and Crop and Livestock Estimates began another coöperative survey of the apple industry, and of the peach industry also. The coöperation included other divisions of the Federal Bureau of Agricultural Economics and the agricultural experiment stations and agricultural extension services of most of the apple-producing and peach-producing States. The study included statistics on the varieties and ages of orchard trees, trends of production market competition between varieties and areas, production practices and costs, and data on supply, demand, and prices. Numerous coöperative publications resulted from this survey and from the farm management and marketing studies which followed. One was jointly authored by the Federal Division (89—54) and the Pennsylvania, Virginia, and West Virginia State agencies. A similar coöperative study of grape management was begun in 1929.

Truck-Crop Management

Sugar beets already have been discussed as a field crop. The statistical aspects of certain vegetable crops, including asparagus, beans, and potatoes, have been discussed under the heading of Special Surveys in the preceding section. Some vegetable crops are included, of course, in the general farm-management studies already presented. Two studies concerned with both fruits and vegetables were discussed above, under Fruit-Crop Management. Only a few coöperative studies have been concerned with individual truck crops.

LIVESTOCK MANAGEMENT

Farm-management and cost-of-production studies concerned with livestock cover the management of general livestock farms, including ranch or range management, and also studies concerned with the different classes of livestock, such as horses, cattle (both beef and dairy), sheep, swine, and poultry, not to mention honeybees. It must be remembered, of course, that livestock management is included in many or most of the coöperative activities previously discussed under the heading, General Farm Management. Only a few of the most striking coöperations can be mentioned. No special coöperative farm management studies relating only to horses have been noted, except those studies of horse labor which are discussed later under Farm Power and Machinery Management.

In these studies the Federal Office (later Division) of Farm Management and the Division of Animal Husbandry in the Federal Bureau of Animal Industry coöperated with many State agricultural experiment stations, and sometimes with extension divisions and State departments of agriculture. In some studies involving marketing aspects, the Federal Division of Livestock, Meats, and Wool and State marketing bureaus took part.

The economics of livestock production were especially important in the cotton-growing South, where diversification was less advanced. A coöperative study in the Coastal Plain area of the southeastern States, begun in 1926, when cotton prices were low, was published by the Federal agency (89—127) in 1929. The bulletin is remarkable in displaying the coöperation in four different places, namely, at the bottom of the cover, on the inside of the front cover, in connection with the scientific titles of the authors, and in the text (p. 9).

Cattle Management

Coöperative farm-management and production-cost studies of beef cattle began in the corn belt in 1912 and have continued through most of the years since that time. Several publications have resulted (95—111; 86—615; 89—23), the last named representing coöperation with five States, Illinois, Indiana, Iowa, Missouri, and Nebraska, indicated in the manner described previously for the Great

Plains study of ranch organization. In 1918, the Federal Office of Farm Management, in cooperation with the Federal Trade Commission, made a study of the cost of beef production on western ranches and in the corn belt, and furnished the data to the Commission.

A general survey of the Appalachian beef-cattle industry was followed by a farm management study begun in 1926. The Virginia portion was published (89—237) in 1931. Similar studies were made in Montana (47—244 and 265), Nebraska (50—215 and 231), and New Mexico (56—159).

From 1921 onward, the Federal Division of Farm Management and Costs cooperated extensively with the State colleges of agriculture and experiment stations in studies of costs of milk production. Early cooperating States were California, New Jersey, New York, Ohio, and Wisconsin. In about 1925, this Division, in cooperation with the Divisions of Statistical and Historical Research and Dairy and Poultry Products, began a general economic analysis of the dairy industry.

In the New England States, New Hampshire (54—275) and Vermont (124—250, 256, and 258) cooperated. A final Vermont study (124—307) was based on data obtained by the U. S. Tariff Commission. From 1923 to 1933, the New York Cornell Station published eleven bulletins resulting from a Federal-State cooperative agreement. The first nine of the studies were concerned with the cost of producing milk under different systems of crop production and dairy feeding (57—421, 433, 438, 441, 442, 452, 455, 462, and 483). The last two were concerned more particularly with dairy-farm management (57—551 and 562). Other studies were made in New Jersey (55—534 and 542) and Pennsylvania (86—1400).

An extensive investigation of the management of livestock ranches in different sections throughout the Great Plains and the Southwest was made from 1922 onward by the Federal Division of Farm Management and Costs and the Division of Animal Husbandry, in cooperation with corresponding divisions of the stations in the States concerned. These cooperative activities resulted in numerous cooperative publications by the U. S. Department of Agriculture (89—45 and 68) and the State stations (11—327,

342, and 394; 60—237 and 255; 73—413; 123—203; 135—147).

The two Federal Bureaus published under joint authorship in 1928 the results of their coöperative study of ranch organization and methods of range-cattle production in the northern Great Plains (89—45). This was one of the early issues of the series called *Technical Bulletins*, which presented coöperative relations on a new and satisfactory basis. The words "United States Department of Agriculture in Coöperation with the Agricultural Experiment Stations of Montana, North Dakota, South Dakota, and Wyoming" appear in capital letters of equal size for both agencies in a box at the bottom of the cover page. A full statement of the coöperation and the personnel involved is printed prominently in heavy type in a box on the inside of the front cover. The scientific titles of the authors, also, show the official agencies they represent. In addition, the State coöperation is repeated in capital letters below the authors' titles on the title page, and likewise is mentioned in the text (pp. 6-7).

In the Southern States, there was extensive coöperation with the Virginia Station in the Shenandoah Valley (125—257), which included also the Federal Bureau of Dairy Industry, and the Richmond Area (125—272). In 1926, the Virginia State Department of Agriculture published a comprehensive survey of the Virginia dairy industry (127—2), containing results compiled jointly by the Federal Bureau of Agricultural Economics and Extension Service and the Virginia Experiment Station and its Dairy and Food, Markets, and Statistics Divisions.

In the North Central States coöperation began with Wisconsin (86—603) and Minnesota (40—173) at least as early as 1915, and has continued through many years. More recently coöperative studies have been made in Iowa (29—243), Kansas (31—255), and Montana (47—264).

In California, the Experiment Station, in 1922 and 1923, conducted a study of the cost of producing market milk in 246 dairies in eleven different sections of the State (5—372), acknowledging financial aid amounting to \$1500 from the Federal Bureau of Agricultural Economics.

Sheep, Swine, and Poultry Management

Numerous coöperative studies have been made on farm management of the sheep, swine, and poultry industries. A sheep survey of the Red River Valley was made by North Dakota (60—186), with assistance from Minnesota State agencies. Federal-State studies were made in Montana (47—249), New Mexico (56—204), Utah (123—204), and Wyoming (135—156), the Forest Service assisting in New Mexico.

Coöperative swine studies in the corn belt, begun in about 1921, were published by the Stations in Illinois (26—390), Indiana (28—338), and Iowa (29—294). Swine production with peanut feeding, studied in coöperation with the Alabama and Georgia Stations jointly, was published by Alabama (1—240).

Coöperative studies of poultry management and costs of production began as early as 1920 and have been continued ever since. Some recent studies have been published by the Stations in Kansas (31—257), New York, Utah (123—244), and Washington (128—216). In 1931, plans were made by the Federal Bureau of Agricultural Economics for a nation-wide study, in coöperation with State agencies, of farm-management, cost-of-production, and marketing problems of the poultry industry, using material previously obtained and making new surveys where necessary.

Honeybee Management

The Federal Division of Farm Management and Costs in 1928 began a study of apiary operation and management in coöperation with the Federal Bureau of Entomology and several State colleges of agriculture in the western intermountain region. This was continued through 1929 and was to be expanded to other regions later.

FARM POWER AND MACHINERY MANAGEMENT

A discussion of the engineering phases of this subject is presented in the chapter on Agricultural Engineering. The farm-management phases are discussed here.

General Power Studies

In 1920, a farm power conference was held in Chicago. Soon thereafter, the Secretary of Agriculture appointed a Federal Committee

on Farm Power, consisting of the chiefs of the Bureaus of Animal Industry and Public Roads, and of the Office of Farm Management and Farm Economics, the latter replaced by the chief of the Bureau of Agricultural Economics in 1922. Following the creation of this Committee, coöperative investigations were begun by the Division of Animal Husbandry, the Division of Agricultural Engineering, and the Division of Farm Management and Costs, representing the three Bureaus concerned.

The Federal Committee on Farm Power published in 1925 a study of all phases of the farm power problem (86—1348). It drew its material from the publications and records of different Federal agencies, including the Federal Power Commission, and from the various State agricultural colleges and experiment stations. In 1933, a publication on power and machinery in agriculture was issued (94—157) by the Bureau of Agricultural Engineering, acknowledging data obtained from Federal and State reports, individual persons associated with State agricultural colleges, and statistical matter from reports of the Bureaus of the Census and Agricultural Economics.

In 1929, the Federal Committee began a new series of coöperative investigations on the use and cost of power on farms in the corn-belt and cotton-belt States in coöperation with ten State agricultural experiment stations. The studies were continued through 1933. The corn-belt study in Indiana, Iowa, Michigan, and Missouri was published by the Committee (89—384) in 1933. In Kansas, the investigation covered the relative economy of horses and tractors under different prices for wheat. The cotton-belt studies were published by some of the States, including Louisiana (33—215) and South Carolina (69—280).

Horses and tractors.—The Office of Farm Management published in 1917 on the cost of horse labor (86—560) in Illinois, New York, and Ohio, the Ohio data being coöperative. In 1919, the Federal Office began a study of the cost of tractor operations, jointly with the Ohio Station. With the creation of the Federal Committee on Farm Power, this and similar collaborative activities came under its supervision. This first joint study covered the cost and utilization of power on 286 farms where tractors were owned in Illinois, Indiana, and Ohio, with some assistance received from the

State Stations (86—997). The more popular results of these co-operative studies in the corn belt were issued as a series of six *Farmers' Bulletins* (87—1295 to 1300) in 1922. All have a full-page statement by the Committee on Farm Power in a box on the inside of the front cover, and a statement on the rear cover that they were joint contributions of the three Bureaus concerned. Five were authored jointly by Agricultural Economics and Agricultural Engineering, and one (87—1298), on the cost of using horses on corn-belt farms, jointly by Agricultural Economics and Animal Industry.

In 1921, the three Federal agencies coöperated with the Kansas and Nebraska Colleges of Agriculture in a study of the use of tractors and horses in the winter wheat belt of Oklahoma, Kansas, and Nebraska (86—1202). From 1920 to 1922, the Office coöperated with the Oregon Station and Extension Division in a study of the cost of using horses, tractors, and combines on wheat farms in Sherman County, and jointly authored the results (86—1447).

Several studies of tractors and horses and (sometimes) man labor and machinery entailed coöperation by the Federal Division of Farm Management only, with State Stations. Among the States were Indiana (28—378), Iowa (29—264), Kentucky (32—274), Montana (47—278), New Jersey (55—386), and South Dakota (71—6).

Motor trucks.—The Office of Farm Management and Farm Economics studied the farm use of motor trucks from 1919 to 1922. The first publication (86—910) recorded assistance from crop reporters of the Bureau of Crop Estimates. A popular account (87—1201) of the same study was a joint contribution from the Office and the Division of Agricultural Engineering, as were a study of the experience of corn-belt farmers with motor trucks (86—931), a popular publication of additional data (87—1314), and another (86—1254) covering the operation of motor trucks on farms in New England and the Central Atlantic States.

Harvesting Machinery

In 1918, the Office of Farm Management published on the efficient operation of threshing machines (87—991), acknowledging assistance from the Office of Cereal Investigations in the Bureau of

Plant Industry and the Division of Agricultural Engineering in the Bureau of Public Roads.

In 1928, the Federal Divisions of Farm Management and Costs, Agricultural Engineering, and Animal Husbandry published jointly on the use of the husker-shredder on farms in the eastern corn belt (87—1589). Later, a study was begun in coöperation with the Illinois Agricultural Experiment Station, on the methods and costs of handling corn by hand, with machine pickers, and with field silage cutters.

Combined harvester-thresher.—In the harvest season of 1926, new economic problems caused an extensive coöperative investigation of the use of the combine on the Great Plains. The Federal Department of Agriculture was represented by the Divisions of Farm Management and Costs, Cereal Crops and Diseases, and Agricultural Engineering, in the Bureaus of Agricultural Economics, Plant Industry, and Public Roads, respectively. The Agricultural Experiment Stations of Texas, Oklahoma, Kansas, Nebraska, and Montana coöperated, each through one or more of its divisions corresponding to the Federal units, and each within the borders of its own State. The results were published in 1928 under joint authorship of the three Federal Divisions (89—70), with the State coöperation displayed prominently on the cover and in the text. Local results were published by the Oklahoma (62—162) and Texas (73—373) Stations.

That portion of the coöperative study made in Kansas and Oklahoma in 1926 which was concerned with the combine harvesting of grain sorghums was published (89—121) in 1929 jointly by four Federal Divisions, the Grain Division of the Bureau of Agricultural Economics also having taken part. The State Stations were represented by their Departments of Agricultural Economics, Agronomy, and Agricultural Engineering. A popular discussion showing the coöperation of all of these agencies was published (87—1577) in 1928. A motion picture film also resulted from the coöperative studies in Oklahoma and Kansas.

In 1927, the three Federal Divisions continued coöperative studies with the Experiment Stations of Illinois, Indiana, Pennsylvania, South Dakota, and Virginia. A popular presentation of the results was published (87—1565) in 1928. The South Dakota Sta-

tion Departments of Farm Economics, Agronomy, and Agricultural Engineering published the results obtained collaboratively and independently in that State (70—244). The Federal agencies also published a popular discussion of the operation and care of the combine (87—1608), including all results obtained collaboratively in the Great Plains and by similar State agencies in Minnesota and North Dakota.

The North Dakota Station, independently in 1926, and in co-operation with the Federal Grain Division in 1927, studied the problem of moisture in grain harvested by this method and published the results (60—220) in 1928 under joint authorship. In 1929, the four Federal Divisions previously named and five North Dakota Station Divisions—Agronomy, Agricultural Engineering, Cereal Chemistry, Farm Management, and Marketing and Rural Organization—joined in a coöperative study of combine problems (60—225).

In Minnesota, in 1928, the three Federal Divisions of Grain, Farm Management and Costs, and Agricultural Engineering, and the four Minnesota Station Departments of Agricultural Engineering, Farm Management, Agronomy, and Agricultural Biochemistry took part in an extensive coöperative study of the engineering and grain-handling problems of the combined harvester-thresher. The results were published (40—256) under joint authorship of the seven divisions, with the coöperation plainly shown in a cover statement and by the professional titles of the seven authors. Fuller details of the costs of combine harvesting were published separately (40—266) in 1930.

Coöperative studies were made by the three Federal Bureaus and the Illinois and Indiana Stations and published (89—244) by the Federal agencies in 1931. Similar Montana studies were published by the State (47—230).

* *Land Clearing*

Land clearing is essentially concerned with special machinery and power sources. The Office of Farm Management coöperated with the Washington Station from 1909 to 1911 on methods of clearing logged-off lands (128—101), although the first specific appropriation and authorization was carried in the Congressional act of

August 10, 1912. In 1912, the Office published (110—239) the results of these coöperative studies on costs and methods of clearing land in western Washington, with a cover statement, "In coöperation with the State Experiment Stations of Washington, Wisconsin, and Minnesota." Text statements show that the contained data on explosives were derived from a joint investigation with the Wisconsin and Minnesota stations, also published by them (40—134; 133—216). Likewise, the information on the charpit method of burning stumps was derived from a previous coöperative publication (129—40).

In 1929, the Division of Agricultural Engineering began a widely extending study of methods and costs of land clearing, in coöperation with various State agricultural experiment stations. Although including cost studies, it apparently was not in coöperation with the Division of Farm Management and Costs. A good example of a study on cost of clearing land, conducted wholly by engineers, is one published in Minnesota (40—299) under joint authorship of the Station Division of Agricultural Engineering and the Federal Bureau of Agricultural Engineering. In Minnesota and Pennsylvania the studies included the removal of stones and boulders. In certain States, a special study was made on methods and costs of clearing land of trees and brush by the use of poisons.

The publications listed in the Literature Cited at the end of this chapter which have been cited in this section on Farm Management and Costs are Nos. 1, 5, 11, 12, 24, 25, 26, 28, 29, 30, 31, 32, 33, 37, 38, 40, 42, 43, 47, 50, 53, 54, 55, 56, 57, 58, 60, 62, 63, 66, 69, 70, 71, 73, 85, 86, 87, 89, 94, 95, 96, 98, 99, 103, 104, 110, 111, 123, 124, 125, 127, 128, 129, 130, 133, 134, and 135.

4. MARKETING AGRICULTURAL PRODUCTS

OFFICIAL ATTENTION to marketing activities and organizations is a relatively recent development. In the last quarter of a century, it has become one of the major interests of agricultural economics. The principal lines of activity have been coöperative marketing by producers, warehousing agricultural products, agricultural marketing extension, product grades, standards, and containers, and product-marketing problems. In 1925, the Federal Bureau of Ag-

ricultural Economics published a bibliography on the marketing of agricultural products (92—35).

Usually, in the various States, the marketing activities are a function of the State department of agriculture, and are conducted by a bureau, division, or department of markets, or by some unit of similar name.

HISTORICAL DEVELOPMENT

Federal marketing activities have been conducted for forty years by the Department of Agriculture. During the first twenty years they were conducted by units not now concerned with marketing problems. The present official marketing agencies, therefore, are only twenty years old.

Federal Marketing Agencies

A Section of Foreign Markets (96—1897:270—78), primarily statistical, was organized in 1894. It was made a subsidiary of the Bureau of Statistics during fiscal years 1904 to 1913, inclusive, and then transferred to the newly created Office of Markets.

In the Bureau of Plant Industry, development of standards and grades for grain was authorized by an act of Congress of March 2, 1901. This Office of Grain Standardization was transferred to the Bureau of Markets in 1917 by an act of Congress. Its activities are now comprised in the Grain Division of the present Bureau of Agricultural Economics. Similar development of cotton standards and grades was authorized in 1908 and transferred to the Office of Markets by Congress in 1915, at the time of a general departmental reorganization.

The Office of Tobacco Investigations published in 1913 a comprehensive treatise on tobacco marketing (110—268), involving, however, no coöperation with other agencies.

In 1913, an independent Office of Markets was established in the Department, and in 1914 its name was changed to Office of Markets and Rural Organization. In 1917, it became the Bureau of Markets, and in 1921 it was combined with the Bureau of Crop Estimates as a new Bureau of Markets and Crop Estimates. In 1922, this combined unit and the independent Office of Farm Management and Farm Economics were merged to form the present Bureau of Agricultural Economics.

In this Bureau, nearly half the Divisions are concerned with marketing. These Divisions, arranged by classes of commodities, are Grain; Hay, Feed, and Seed; Cotton Marketing; Tobacco; Fruits and Vegetables; Livestock, Meats, and Wool; Dairy and Poultry Products; and Warehousing. The administration of the Cotton Futures Act is entrusted to the Division of Cotton Marketing. The Grain Futures Act, however, is administered, not by the Grain Division of this Bureau, but by a Grain Futures Administration, independent of any Bureau of the Department. The Bureau originally contained a Division of Cost of Marketing, but it soon was discontinued.

Development of Coöperative Activities

After the creation of the Office of Markets in 1913, informal cooperation with State agencies developed rapidly. One of the first studies undertaken was a survey of State marketing activities throughout the United States, published (108—3) in 1916. Naturally, this entailed numerous coöperative relations with official marketing agencies in the various States. At the same time, the way was paved for more formal and specific relationships.

Coöperation with the States in the employment of State marketing agents was authorized in the Appropriation Act for the fiscal year 1917. The first year was devoted to making contacts, the selection of joint representatives, the formulating of coöperative agreements, and the outlining of detailed work to be undertaken. These agreements became effective between August, 1916, and May, 1917, in different States. The purpose was to assist the States in acquiring and diffusing information on marketing farm products. In that year, nineteen States were assisted, first in observing their marketing problems, and then in specific studies. Coöperation was with State bureaus of marketing, commissioners and departments of agriculture, agricultural extension divisions, or other State agencies. State and Federal publications containing the results of these coöperative beginnings soon appeared, including one each from the North Dakota Extension Division, the Arizona Station (2—85), and the Nebraska Station (52—5).

By 1919, coöperative activities were under way in twenty-two States, and thirty-one States took part in fiscal year 1920. In

twenty-one of these, the Federal Bureau of Markets coöperated with the State college of agriculture; in six others, with the State division of markets or the State department of agriculture; and in four others, with both the agricultural college and the State division of markets. The thirty-one States coöperating at this time were:

Arkansas	Kentucky	Nebraska	South Carolina
California	Maine	New Hampshire	Tennessee
Colorado	Massachusetts	New Mexico	Texas
Connecticut	Michigan	North Carolina	Utah
Delaware	Minnesota	North Dakota	Vermont
Georgia	Mississippi	Ohio	Virginia
Indiana	Missouri	Oregon	Washington
Iowa	Montana	Pennsylvania	

It was the avowed purpose of the Federal and State agencies to develop this new field in ways helpful both to producers and consumers, to prevent duplication of effort and working at cross purposes by Federal and State agencies, and to coördinate all existing marketing agencies within the borders of each State. The Federal coöperating agents in the several States acted as coördinators within the State to which they were assigned, and made available to State workers the results obtained in other States.

By 1920, a large volume of work in connection with marketing demonstrations, extension, and exhibits, was done in coöperation with the various States. This included assistance to the States in starting market reporting services, and in adopting the Federal standards for commodities and containers. Some two hundred demonstrations of correct practices in preparing products for market were given, as well as seven hundred lectures on marketing, including packing, grading, and handling. Assistance was given also to county agents on local marketing problems.

A summary of the Department's activities in the field of marketing, made by the Secretary of Agriculture in 1919, illustrates the scope of the possible and actual coöperation with the States (85—1919:33). Included are standardization of the production, packing and handling of farm products; the promotion and use of standard containers; proper storage on farms, in transit, and in market centers; more complete statistical information; better accounting

systems; market-news services giving daily facts on market prices, supplies, and demands, all exceedingly important to producers; inspection services on fruits and vegetables covering 164 markets; compilation of reports on supply, commercial movement and prices of the most important products; and coöperation with fourteen States in issuing exchange marketing lists informing county agricultural agents and stock breeders and feeders in those States as to whereabouts of supplies of livestock, feeds, and seeds.

Beginning in about 1921, the plan of work in coöperative marketing in the different States gradually was changed. The original idea was to employ joint agents to aid in planning and conducting general marketing studies. The new plan was to assign Bureau specialists to individual States for a definite time period to coöperate with State specialists on specific problems. This was a natural and logical development of the work of marketing and resulted in making the coöperation with State agencies larger than ever before.

Among the specific problems thus coöperatively studied were costs and methods of marketing specific agricultural products, marketing by coöperative organizations, perfecting of the existing standards for fruits and vegetables, and formulation of standards for still others. Assistance was given also in developing a food-products and inspection service, and coördinating it with the Federal inspection at receiving points.

At this time, coöperative agreements were in force with thirty-three States. In eighteen, coöperation was with the State bureau of markets and the State department of agriculture. In twenty-four, there was coöperation with the State experiment station or extension division, or with departments of the State college of agriculture. In five States there was coöperation with still other agricultural institutions or with farm organizations. In New England, the New England Food Council on Marketing and Food Supply was established in 1922, with representatives from all research institutions, to correlate the research conducted by Federal and State agencies in that area.

From 1931 to 1933, the Division of Statistical and Historical Research made extensive studies on the relation of transportation facilities and costs to the agricultural situation. This also included

the effect of the proposed railroad consolidation. Much of this material was prepared at the request of the Interstate Commerce Commission for its use in holding hearings on proposed freight rates on agricultural products. In connection with the work of the Agricultural Adjustment Administration and the National Recovery Administration, this Division compiled extensive data on production and consumption and the effect of different price levels on such consumption.

In coöperation with the National Association of Marketing Officials, a marketing legislation service has been conducted during recent years, current changes in State and Federal laws being reviewed in a weekly Federal mimeographed periodical entitled *Marketing Activities*.

SPECIAL MARKETING STUDIES

In discussing specific marketing activities conducted coöperatively by Federal and State agencies, it is logical to divide them into special marketing studies and commodity marketing studies. Under special studies are included early investigations in marketing by parcel post, municipal marketing, and wartime food surveys, as well as the more extensive studies of foreign markets, warehousing, and the organization and activities of coöperative marketing associations. Those special studies concerned with grades and standards for specific agricultural commodities and the market-news services concerning these commodities are so intimately associated with the specific commodities themselves that they are discussed under Commodity Marketing Studies.

Early Special Studies

Three limited studies carried on in the early years of the Bureau of Markets were concerned with marketing by parcel post, municipal markets, and wartime food surveys.

Marketing by parcel post.—In about 1913, the Office of Markets began studies of the direct marketing of farm products by parcel post, with the informal coöperation of various representatives of the Federal Post Office Department. The work done consisted in field studies and experimental shipments, the latter numbering more than 1800 in 1916. The field studies in and around different

cities were conducted in coöperation with their postmasters. The first publication covered the shipping of eggs (87—594). After coöperative field studies covering thirteen cities, it was rewritten (87—830) in 1917, with Post Office Department coöperation prominently shown on the inside cover. Suggestions for parcel-post marketing were issued (87—703) in 1916. The studies were continued on an increasing scale into 1920, emergency funds being used during the war. Investigations were made of territories served by rural parcel-post routes centering on Baltimore, Philadelphia, and Washington. Other publications resulting were parcel-post business methods (87—922), marketing butter and cheese (87—930), and marketing berries and cherries (86—688), all issued in 1918. The shipments were made to different State agricultural experiment stations for reports on quality and condition on arrival.

Municipal markets.—Beginning in about 1915, the Office of Markets and Rural Organization coöperated with nine cities in making surveys for the establishment and management of municipal retail markets, or of such markets combined with farmers' retail markets. A tenth State, West Virginia, established a municipal market with coöperative assistance from the Federal Office. In each of several years thereafter, surveys were made and information given on municipal markets in ten or a dozen cities annually, following request from city officials, city planning commissions, or civic organizations. Most of these comprised extensive market surveys and plans and estimates for market buildings. In coöperation with the Virginia Bureau of Markets, a survey was made in Richmond and a comprehensive plan for a public-market system formulated. On account of a reduction in appropriations, all work of this character was discontinued on June 30, 1920.

War-time food surveys.—During the progress of the World War, close coöperation was effected between the Bureau of Markets and the Bureau of Crop Estimates (in the U. S. Department of Agriculture) and the U. S. Food Administration in determining location and quantity of various food products from time to time.

A food survey made as of December 31, 1917, by means of more than 500,000 inquiries, was compiled rapidly and the information made available to interested public agencies. Two comprehensive surveys of commercial food stuffs were made by these three Fed-

eral agencies. The first, as of August 31, 1917, covered eighty items, and the second, as of January 1, 1918, covered eighty-six items. The results of the first were published in six of the *Circulars* of the Office of the Secretary (112—96—101) in 1918, and covered sugar, lard, canned salmon, miscellaneous cereal and vegetable foodstuffs, wheat and flour, and miscellaneous animal food products, respectively. A third comprehensive survey of commercial products covered sixty-seven food commodities as of July 1, 1918. In this case, reports on household consumption were obtained in coöperation with the States Relations Service, which at that time included the Office of Coöperative Extension Work.

Special attention was given to cereal crops. As part of the production survey of cereals, reports were obtained from threshermen through the coöperation of the Agricultural Extension Service in the States Relations Service in 1918. In coöperation with the U. S. Food Administration and the Bureau of Markets, specialists in grain production were sent to Australia to arrange for the selection and inspection of wheat accumulated there and to be transferred to the United States.

Assistance was given by the Bureau of Markets to the Quartermaster Corps of the Army, to the corresponding unit of the Navy Department, and to the U. S. Food Administration in handling and conserving meat products in storage and transit. Under an act of Congress of August 10, 1917, a Food Products Extension Service was created by the Bureau of Markets, under rules and regulations laid down by the Secretary of Agriculture (112—82) and revised under law in 1918 (112—120). The inspectors coöperated with the U. S. Food Administration and with supply officials of the Army and Navy.

The Bureau of Markets rendered assistance to the U. S. Food Administration also in formulating regulations on the distribution and marketing of cold-storage food products, based on research conducted (96—1917:363—70). On behalf of the Quartermaster Corps of the United States Army, the Bureau made a survey of the quantity of storage space available in the country.

From April, 1918, onward, monthly reports on commercial stocks of grain products, sugar, condensed milk, and canned goods were obtained and published monthly under the title *Food Sur-*

veys. All surveys and publications of this character were discontinued on June 30, 1919, with the expiration of the emergency appropriation.

Foreign Markets

Beginning in June, 1916, representatives of the Office of Markets and Rural Organization began a study of markets and marketing agencies in Europe, with reference to exports of American agricultural products. This study was conducted with the cooperation of the diplomatic and consular services of the Federal Department of State and commercial officers of the Department of Commerce (105—1917:447).

In about 1920, the Department of State, in cooperation with other interested Departments, formed an Economic Liaison Committee to coordinate the efforts of all government agencies concerned with foreign trade, including one representative from the Bureau of Markets of the U. S. Department of Agriculture. Apparently this committee later was dissolved, for in 1930 a new liaison committee was created, consisting of one representative from each of four Federal agencies, namely, the Departments of State, Agriculture, and Commerce, and the Federal Farm Board (98—1930:64).

Between 1920 and 1925, because of the general agricultural depression, there was a steadily increasing activity in the cooperative exchange of agricultural statistics and other information with foreign countries. In 1922, two representatives of the Federal Bureau of Agricultural Economics were sent to Europe to make an economic survey of agricultural reconstruction and to arrange for full interchange of crop data. By 1923, the Bureau had placed two permanent agricultural commissioners in Europe, stationing one in Berlin, and the other in London. By 1925, others were placed in Vienna and the City of Mexico. Three other staff members of the Bureau also were stationed in Europe. A large volume of market information on agricultural products was exchanged with the International Agricultural Institute at Rome, as discussed in a preceding section on Estimates and Statistics. The U. S. Naval Radio Service transmits reports from Rome, Berlin, and London without expense to the Federal Bureau except for the cost of commercial wire connections.

By the end of the first quarter of this century, a very large volume of information was being sent abroad and received from foreign sources. The International Institute of Agriculture transmitted reports from seventy countries. Additional and more detailed material was received directly from foreign Ministries of Agriculture. The four hundred consular officers of the Department of State and the attachés and commissioners of the Department of Commerce contributed market data from their stations. By agreement between the Departments of Agriculture and Commerce, the files of the Bureau of Foreign and Domestic Commerce were opened to representatives of the Bureau of Agricultural Economics, and vice versa. A representative of the latter Bureau was detailed to travel abroad and arrange for the gathering of more complete international crop statistics in the various countries of the world, looking toward a uniform international census of agriculture in 1930.

Enormous statistical compilations by the Division of Statistical and Historical Research, on production estimates and statistics, stocks, movements, prices, and demands for foreign agricultural products and prospective demands for American agricultural products abroad, made full use of this coöperatively gathered information.

In 1930, the Federal Congress enlarged the foreign agricultural service and the Bureau added representatives at Belgrade, Buenos Aires, Pretoria, and Sydney. Commodity specialists to work through these foreign marketing offices were increased from one to eight. The coming of the depression, however, and the consequent necessary economies greatly reduced the personnel of this service.

A report prepared by the Bureau and other agencies on rural trade barriers in relation to American agriculture was printed as Senate Document 70 of the 73rd Congress in 1934.

Warehousing

The U. S. Warehouse Act was passed in August, 1916, to aid producers and merchandisers of agricultural products to borrow money on such products while in storage. Conditions previously had been very unsatisfactory as regards the character of storage,

the storage practices, character of receipts issued, and the financial standing of many warehousemen. The administration of the act was entrusted to the Secretary of Agriculture and a Division of Warehousing created in the Office of Markets and Rural Organization, and continued in the Bureau of Agricultural Economics.

Two major problems, naturally, were encountered in the development of operations under the Federal Warehouse Act. The first was the formulation of grades for the different commodities admissible to storage and the issuance of warehouse receipts and the determination of standards by which such grades could be determined. Without such grades, of course, the value of the warehouse receipt as collateral for loans would be doubtful. The second problem was to train a sufficient force of inspectors and graders familiar with the standards for each of the commodities permitted licensed storage. Much official and commercial coöperation has been obtained during the nearly twenty years of the operation of this act.

The coöperation of banks, including those of the Federal Reserve System, was necessary to the successful functioning of the Warehouse Act. Without the willingness of money-lending agencies to accept the receipts from licensed warehousemen as collateral for loans, the system could have no value. In 1919, negotiations were made with the Federal Farm Loan Board and the Federal Reserve Board for approval of the forms of receipt to be issued under the warehousing regulations. From 1920, the Federal Reserve Bank of the Atlanta district vigorously encouraged warehousemen to become licensed and bonded. The Federal Reserve Bank of the Dallas district also circularized its member banks in favor of the warehouse system. In 1924, the Federal Reserve Bank of St. Louis, by resolution, thereafter accepted warehouse receipts as collateral only when agricultural products were stored under the Federal Warehouse Act.

In about 1919, North Carolina provided a State system of warehousing, and the Federal Bureau of Markets coöperated therewith. A later amendment was designed to bring under the Federal Warehouse Act all warehouses operated under the State system of licensing and bonding. By 1920, a coöperative agreement had been made with the Georgia State Bureau of Markets whereby it fur-

nished free grading service to warehousemen licensed under the Federal system. In South Carolina, an agreement was made by the Federal Bureau of Markets with the State Warehouse Commission, the State Agricultural Extension Service, and the American Cotton Association to promote the development of farmers' associations and an adequate warehousing system in the State. The Alabama Agricultural Experiment Station made request for similar service at that time. Much later, under a coöperative agreement of 1929, the Federal Division of Warehousing and the Alabama State Department of Agriculture began joint administration of both the State and Federal Warehouse Act in Alabama (98—1930:56).

In California, the State Superintendent of Weights and Measures desired to coöperate in 1920. The State certificates and receipts were changed in order to avoid any conflict of requirement, and collaboration was effected in the joint use of warehouse inspectors. In Idaho, the largest farmers' coöperative organizations operating grain elevators joined hands in the use of their warehouses and also undertook to obtain needed State legislation. In about 1929, the Federal Division of Warehousing entered into co-operation with the Warehouse Divisions of the California and Idaho State Departments of Agriculture in opening coöperative field offices at Sacramento and Boise, the latter covering the State of Utah also.

The Division of Warehousing has received coöperation from the State colleges of agriculture in the holding of schools for the training of graders for commodities. This has been part of the larger movement necessary in establishing Federal and State standards and grades for various agricultural commodities.

Coöperative Marketing Organizations

The coöperative marketing of agricultural products through co-operative associations of producers has been developing during the past seventy years, but has increased enormously in the last twenty years. From the organization of the Office of Markets in 1913 until the end of the World War, many official marketing agencies, Federal and State, were concerned with obtaining and publishing a full knowledge of the organization, management, and methods of

coöperative associations and the problems of coöperative marketing. These studies resulted in numerous publications. There was relatively little sharing in the research but an increasing collaboration in extension.

In 1917, the Federal Office of Markets, jointly with the Office of the Solicitor, compiled and published in the Service and Regulatory Announcements (No. 20) suggestions for a State coöperative law designed to conform to Section 6 of the Clayton Act. By 1920, it was recorded that the suggested law had served as a guide to four States in the enactment of legislation on coöperative marketing.

In 1923, there was published a selected and annotated reading list on agricultural coöperation, with special reference to purchasing, marketing, and credit (92—11). A revision of this list (92—97) was published in 1927, and again brought up to date in 1931 by the Division of Coöperative Marketing, then in the Federal Farm Board (16—6).

Agencies of the Federal Government, usually the Department of Agriculture, have made at least five national surveys to determine the extent and character of the movement for agricultural coöperation. The first, begun in 1913 by the newly formed Office of Markets, was published (86—547) in 1917. The second was made in 1919 by the Federal Bureau of the Census. The third was begun in 1922 by the Division of Coöperative Marketing, with assistance from some 60,000 Federal-State crop reporters. This publication (86—1302) covered the status of 10,000 associations in five separate years, 1913, 1915, 1919, 1921, and 1923. In 1927, the Division obtained and published (89—40) data from 11,000 coöperative associations. In 1929, another survey, with assistance from the Federal-State Agricultural Extension Service, obtained reports from 8,000 out of about 11,000 active associations on record (90—94).

Extension activities in coöperative marketing.—The creation of a nation-wide system of Federal-State coöperation in agricultural extension in 1915 was coincident with a large increase in Federal activities in the promotion of coöperative associations for marketing agricultural products. Extension and research in this field, therefore, progressed together. Because marketing of agricultural commodities was a new subject, the regular county agricultural agents had not been trained in it. It was necessary, therefore, that

the Federal Bureau of Markets assist in training them. By 1919, the Bureau was coöperating with twenty-three different States in the employment of specialists to advise agricultural extension workers in the promotion of associations of farmers for coöperative marketing. At that time, it was estimated that the existing associations were marketing farm products with a value of \$1,500,000,000 annually.

One of the major extension activities of the Federal Division of Coöperative Marketing was the holding of short courses in connection with the State colleges of agriculture and their extension services. These closely paralleled the earlier developments of the farmers' institute movement in agricultural production. This work developed rapidly from 1926 onward. In 1927-28, such short-time schools of coöperative marketing were held in Arkansas, Connecticut, Colorado, Kansas, Massachusetts, Missouri, Tennessee, and Texas. They received the active support of the coöperative associations themselves, with many members and employees of the associations and many county agricultural agents and agricultural teachers in attendance. In Mississippi, a coöperative council representing the Agricultural College, the State Department of Markets, and the coöperative marketing associations themselves, took the initiative in arranging for such a school. In Colorado, the State Board for Vocational Education assisted the other agencies.

Beginning in about 1926, the Federal Division of Coöperative Marketing began to develop a series of motion pictures illustrating the coöperative marketing of farm products, to which was added also a series of glass and film-strip lantern slides. A bi-weekly circular entitled *Agricultural Cooperation* was developed as early as January 1, 1923, and continued at least through 1928.

The Division also gave assistance to State bureaus of markets, to State officials engaged in agricultural-marketing studies, and to groups of producers, on the organization, improvement, or reorganization of coöperative associations.

Investigations of coöperative marketing.—A few studies of coöperative marketing were made by the Federal Office of Markets and State agricultural experiment stations soon after the creation of the Federal unit in 1913. In 1916, the Federal Office coöperated with the Oregon Agricultural College in a survey of the organiza-

tion and maintenance of coöperative stores, accounting systems (86—381) and typical coöperative stores (86—394) being discussed. In 1917, the Federal Office of Markets and Rural Organization and the Federal Dairy Division published a jointly recommended system of accounting records for country creameries (86—559). In 1919, the Federal Bureau of Markets coöperated with the Minnesota College of Agriculture in publishing a system of book-keeping for grain elevators (86—811). In 1920, a coöperative survey of typical farmers' creameries in Oregon was published by the Oregon Station (63—168).

A Division of Coöperative Relations was created in the Federal Bureau of Markets in about 1921 to conduct research in coöperative purchasing and marketing and to work together with the States in marketing matters, including those of producers' coöperative associations. With the creation of the Bureau of Agricultural Economics in 1922, this became the Division of Agricultural Coöperation.

The Coöperative Marketing Act, approved on July 2, 1926, provided for the creation of a Division of Coöperative Marketing in the Federal Bureau of Agricultural Economics, and made possible a large expansion. With the creation of the Federal Farm Board by Congress in 1929, the Division of Coöperative Marketing was transferred to the Board. In 1931, the Board issued a selected and annotated bibliography on coöperation in agriculture, with special reference to marketing, purchasing, and crediting (16—6).

The Federal Division of Coöperative Marketing made numerous studies in common with various official agencies. Those of general nature are discussed first and then those concerned with specific commodities.

In California, a joint survey of coöperative marketing organizations was begun in 1925 and completed in 1926. Several years later, two joint studies of farm organizations in California were made by the State Station. The first, covering farm organizations in the Turlock area (5—544), published in 1932 by the Division of Farm Management, acknowledged special coöperation of the Federal Bureau of Agricultural Economics and the farm advisor of Stanislaus County. The second, a comprehensive study of the objectives and activities of the California Farm Bureau (5—563), was made by a staff member of the Department of Rural Eco-

nomics of Ohio State University, released temporarily by that institution for the California study. Acknowledgment was made to the Division of Markets of the California State Department of Agriculture, to the Federal-State Agricultural Extension Service, including many county farm advisors, and to State and local officers of the Farm Bureau, Farmers' Union, and Grange.

In Florida, an extensive intrastate coöperative study was made of farmers' coöperative associations, in which the Department of Agricultural Economics in the Florida Station and the Department of Marketing in the Florida College of Agriculture coöperated, with assistance from the Office of the Secretary of State. Two Station bulletins under joint authorship resulted, covering the status and legal phases (20—245), and the organization and management (20—263), with the coöperation of the Experiment Station Division of the College and of the Division of Resident Teaching shown on the cover page. So far as noted, these are the only cases where the coöperation of these major divisions of the College of Agriculture has been indicated in this way, although coöperation between the teaching departments and the experiment station is not at all uncommon.

Other joint Federal-State studies of coöperative agricultural marketing were made in coöperation with the Kentucky, Michigan, Minnesota (41—45), New York Cornell (57—544), Ohio, and Vermont (124—346) Stations, the New York study including the State Department of Agriculture and Markets also.

Coöperative studies by Federal-State official agencies covered the producers' coöperative organizations concerned with individual crops or products. One of the most important covered grain, especially farmers' coöperative elevators, a five-year study being made from 1925 onward in Minnesota (40—224 and 251), Montana (47—226), North Dakota (60—206 and 272), and South Dakota (70—282). Similar studies were conducted in Colorado (11—397), Illinois, Kansas (31—246), and Missouri (45—311).

Federal-State investigations of coöperative cotton marketing were published in Arkansas (3—245), and Oklahoma (62—178). Two recent interdivisional investigations of the Federal Bureau covered farmer opinions related to cotton marketing (90—144) and agricultural credit affiliates of coöperative marketing associa-

tions (89—322). An earlier joint investigation of coöperative potato marketing in Minnesota was published (40—195) in 1921.

Coöperative marketing organizations concerned with livestock and poultry have been investigated by Federal and State agencies coöperatively. A comprehensive Ohio investigation of livestock-marketing associations (61—375) was partly coöperative with the Federal Division. Creameries were covered by an early Oregon study (63—168) and a recent Kansas (31—259) investigation.

Fluid-milk coöperative marketing associations were studied in New York and Ohio, and cheese factories in Wisconsin (134—100 and 103). Coöperative associations for marketing poultry and poultry products were investigated in common by Federal-State agencies in Ohio (61—427) and independently by the Federal agency (90—111) in California.

In Minnesota, where farmers' associations for coöperative oil purchasing have developed, a Federal-State study was made and published by the Federal agency (90—80) in 1929.

Commodity and Container Classes, Grades, and Standards

One of the most important developments in recent years in commodity marketing has been the establishment of national standards, under which the various agricultural commodities can be classified into market grades and more honestly and effectively marketed. Naturally, the commercial trade in agricultural commodities had erected its own standards, but these varied greatly from place to place, were not defined accurately, and often were a source of dissatisfaction both to producers and purchasers. The Federal Bureau of Plant Industry began studies of standards for grain and for fruits and vegetables soon after the turn of the century. State agencies did likewise. With the creation of the Office of Markets in the Federal Department of Agriculture in 1913 and its elevation to Bureau status in 1917, standardization of agricultural products drew increasing attention.

The first step is to determine the actual classes or kinds (as, for example, long-staple, short-staple, and linter cottons) into which a commodity must be separated for commercial marketing purposes. The second step is the determination of grades for each class

of any particular agricultural commodity. The third step is the formulation of the standards or definitions which mark the limits between classes, and between grades for any given class of any commodity. In general, classes are more or less natural divisions, recognized by the producer, the handler, and the manufacturer. Grades, on the other hand, are arbitrary limits which must be defined with accuracy, and which are recognized readily only after training and experience. In many cases, they must be verified by tests, counts, measures, etc.

Classes and grades, with their accompanying standards, have now been formulated for almost the entire range of agricultural products. The grain standards and the cotton standards have been made official United States standards by Federal law and must be used whenever these products are sold in interstate commerce. The standards for other commodities are recommended by the Federal Bureau but their use is optional, except so far as they are required by State laws.

The coöperative activities in connection with the standardization of the various commodities will be discussed under the marketing of the commodities themselves. Summaries of the progress made have been published from time to time. A discussion of the march of standardization was presented by the Federal Department (96—1920:353) in 1921, showing the progress made in official and tentative standards for grains, vegetables, fruits, and containers. Again in 1927, the necessity and development of national standards for farm products were discussed (90—8).

The standardization of containers was chiefly a matter of shape and size, and effective national legislation was relatively simple. The U. S. Standard Container Act, covering small containers, was approved in 1916 (112—76), to be effective on November 1, 1917. Thereafter, the Federal Bureau coöperated with officials of various States and the District of Columbia in promoting legislation on container standards. A later act of 1928 standardized hampers and baskets. By 1932, some 166 different sizes and shapes had been reduced to 35 standards. Recent discussion of this subject, covering standard sizes (96—1928:213) and methods of testing capacity (94—75) appeared in 1929 and 1930.

Inspection and Certification

The development of grades and standards for different commodities and the adoption of some or all of these standards by various States created a demand for an adequate inspection service. The purpose is to furnish certificated evidence, by a disinterested party, of grade or condition of product at time of inspection. It thus subjects standards to practical test in commercial transactions, and also has large educational value in demonstrating grades and educating producers and dealers as to quality.

Terminal-market inspection.—Inspection of food products, especially fruits and vegetables, at terminal markets was authorized by the Congress and begun in November, 1917, as a wartime activity of the Federal Bureau of Markets, on emergency funds provided under the Food Production Act. Inspectors were sent into 30 major terminal markets, in coöperation with State and commercial marketing agencies, and were available for service in 134 additional surrounding cities (96—1919:319). Although the scope of the work was decreased in 1919, after the termination of the act, it gradually has been extended since to cover substantially all agricultural commodities of commercial importance. In 1932, inspection at 350 receiving markets covered about 335,000 carloads, or approximately 30 per cent, of the total shipments of fruits and vegetables.

In many cases, this inspection was done in coöperation with State agencies, in two cases in connection with the market news services, and at Norfolk, Virginia, and San Francisco, California, it was done by men assigned to inspect purchases by the Navy Department. The field staff of the Division assisted growers and shippers in interpreting and using the promulgated grades, this work being done both independently and in coöperation with State and local agencies.

Shipping-point inspection.—As early as 1920, the Federal Bureau of Markets coöperated with the California State Department of Agriculture in planning the details of a shipping-point inspection service to be conducted by the State Department.

In 1923, the Congress authorized Federal participation in shipping-point inspection by amending the law authorizing the inspec-

tion service, but provided no additional appropriations. The work was inaugurated, therefore, in coöperation with State agencies, which either had such appropriations or had authorization to use as a revolving fund fees collected for inspection. The coöperative agreements were made with twenty-six States, as follows (98—1923:167):

California	Maine	New York	Utah
Colorado	Massachusetts	North Dakota	Virginia
Delaware	Missouri	Oregon	Washington
Florida	Montana	Pennsylvania	West Virginia
Georgia	Nebraska	South Carolina	Wisconsin
Idaho	North Carolina	South Dakota	
Illinois	New Jersey	Texas	

Most of the work was done in a few States having revolving funds. The coöperative agreements varied in different States. The prevailing type provided that the State collect and disburse the fees. In such cases, the State hired inspectors while the Federal Department trained and supervised them, receiving a small share of the fee to offset this cost of supervision. All States operating successfully are using fees to support the work, which makes the service practically self-supporting.

For fiscal year 1923, the shipping-point inspections totaled nearly 73,000 cars, of which nearly 25,000 were in Colorado and nearly 18,000 in California, both coöperating States. In 1929 they totaled 229,000 cars in more than forty States and substantially all under coöperative agreements.

In California and Colorado, supervisors of shipping-point inspection were employed jointly by the States and the Federal Bureau for the entire fiscal year 1930. In Indiana, Louisiana, Ohio, and South Carolina, these coöperatively employed supervisors devoted some time also to extension work in grading and standardization. Full-time Federally employed supervisors were maintained in Idaho, Oregon, Utah, and Washington. Since 1931, very nearly all shipping-point inspections have been made in coöperation with State agencies, forty-four States coöperating in 1932 and forty-five in 1933.

Market News Services

The Market News Service keeps all interested persons promptly and accurately advised of essential current and historical informa-

tion on the different phases of agricultural industries, including production, storage holdings, consumption, distribution, local and national market movements, and market conditions and prices, not only as of any State, but also as of the country at large. Such service is of prime economic importance to those actively engaged in producing and marketing seasonal and often perishable agricultural products, and to those engaged also in the processing and the commercial handling of farm commodities and their products. It is conducted through an unbiased coöperating national and state market news agency, with the aid of commercial agencies.

Market news is distributed principally by mail, press, telegraph, and radio, or by combinations of these. Speed is the essence of a market news service for agricultural commodities, many of which are perishable. Much of this market information is distributed daily. The daily and weekly news service is published in the form of news releases issued to mailing lists from the State offices, and also to commercial wire companies, to press associations, and directly to metropolitan and rural newspapers, and to certain trade and agricultural publications. The reports also are posted in part on local bulletin boards, transmitted on certain circuits of a leased wire system, and put on the air through various official and commercial broadcasting stations. It is estimated that market information is made available daily through all these channels to at least 15,000,000 readers and hearers.

Early and war-time development.—The market news service, conducted by the Federal Bureau of Agricultural Economics in coöperation with various State agencies, was developed as the result of unsatisfactory market conditions for agriculture. Lack of knowledge of shipments, destinations, and receipts caused a glutting of some markets, while others were insufficiently supplied, with the result of losses to producers, shippers, and jobbers. Also, some misleading information was supplied by interested agencies. To remedy these conditions, beginnings of the market news service were made in 1915 by the Federal Bureau of Markets, with a few fruits and vegetables. From this small start there developed rather rapidly a service which, by 1919, was covering, for major sections of the country, all the important classes of agricultural commodities, including grain, hay, feed, seed, cotton, fruits, truck crops,

livestock, meats, wool, dairy products, poultry products, and honey, but not tobacco. The Bureau was engaged in coöperation with State marketing agencies in twenty-seven States by that year, not only in obtaining such market information but also in studies of specific marketing problems.

Funds made available to the President under the Food Products Act of 1917 were used to expand the then relatively small activities of the market news service. Many of the reports were prepared directly for, or at least used regularly by, such Federal agencies as the U. S. Food Administration, U. S. Shipping Board, and the War Trade Board. The city market service was maintained in coöperation with local representatives of the Food Administration. Fair-price lists were published in various cities, in coöperation with Federal and local Food Administrators. Surveys of supplies of foodstuffs were made in certain sections for the Food Administration, and information on seed stocks was assembled for the Seed Stocks Committee of the Federal Department of Agriculture and for the War Trade Board. In 1918, a survey of the quantity of soft corn requiring immediate shipment was made for the U. S. Railroad Administration.

Coöperating agencies.—The Federal agency responsible for the Market News Service is the Bureau of Agricultural Economics. It includes many commodity marketing Divisions, each charged with the collection, assembling, preparation, and distribution of the information on the commodities it represents.

In the various States, two different classes of agencies are concerned with market news. The first is the State division, bureau, or department of marketing, either independent of or a component of the State department of agriculture. This State unit may comprise also several commodity divisions. It is concerned with both the collection and the distribution of market news. The second State agency is the college of agriculture, wherein the chief coöperating unit usually is the extension division, which is in itself a part of the Federal-State Agricultural Extension Service. There is coöperation also from the press service or other informational agency of the college and from the division or department of agricultural economics, these units of the college being concerned chiefly with the distribution of news.

Recent coöperative activities.—Coöperation between Federal and State agencies usually takes the form of joint maintenance of branch offices or of temporary field stations, the joint operation of leased wires, and the provision of radio services.

In 1920, the Federal Bureau of Markets had sixteen branch offices, at large market centers, which were directly connected with the Washington office and with each other by leased telegraph wires. Not less than 15,000 responsible voluntary reporters, individual persons, business firms, and railroad companies, reported regularly to the Bureau. Since 1930, there have been twenty-two permanent branch offices, all connected by leased wires, of which sixteen were maintained in coöperation with State agencies. In addition, there have been about forty temporary field stations each year, practically all operated with some financial assistance from the States in which they are placed. Since 1929, no temporary field stations have been added unless approximately half of the expenses were borne by State or local agencies.

In California, coöperation was arranged by the Federal Bureau of Markets with the California State Department of Agriculture, and a special livestock reporting service begun, in September, 1922, at San Francisco and Los Angeles. Office space was furnished by the State in the offices already occupied in these cities by the State Division of Markets, and each party to the agreement arranged to pay one half of the total expenses. The Federal Bureau assigned two trained livestock reporters to the work, and the furnishing of daily and weekly reports on livestock trade was begun, with price quotations based on tentative grades. Other market information received direct from Washington, D. C., was mimeographed and released by the State Division. In 1923, the leased wire service was extended coöperatively to San Francisco and, at the same time, fruits and vegetables were added to livestock (7—13 :228). In 1924, dairy and poultry products likewise were added. The scope of the coöperation was still further enlarged in 1928, grain and hay being added. A Federal branch office was established in Los Angeles in 1929.

Leased wires: As the leased wire network was extended more widely over the United States by the Federal Bureau of Agricultural Economics, more and more State agencies coöperated in con-

necting with this system in order to distribute market information promptly. Sometimes this was accomplished through coöperation at a branch office or temporary station in the city where the State agency was located. In other cases, the State bureau of markets or other agency paid or shared the expense of installing a loop of the leased wire to reach from some nearby point to their own location. In 1920, State officials of Pennsylvania coöperated in installing such a loop at Harrisburg.

In coöperation with the California State Department of Agriculture, San Francisco was connected by leased wire on July 1, 1923. Similar services already had been established in coöperation with State agencies in Missouri, Ohio, New York, Pennsylvania, Texas, and Wisconsin. North Carolina and Virginia were added in 1924. In 1926, the Congress provided for extension of the leased wire service to the Iowa State College to take advantage of radio privileges. A similar extension was made in coöperation with the Oklahoma State Board of Agriculture. Leased wires were extended to four more State headquarters in 1930, and to Fargo, North Dakota, in 1931.

Radio: Considerable official coöperation has been developed in the use of broadcasting stations for purposes of the market news service. In 1920, coöperation was arranged between the Federal Bureau of Markets and the U. S. Bureau of Standards in the Department of Commerce by which the transmitting station of the Bureau of Standards was used for sending out market information within a radius of some two hundred miles of Washington, D. C. In 1922, market news was being broadcast daily at designated hours over the Arlington (Washington, D. C.) and Great Lakes Stations of the Navy Department and six stations of the Post Office Department. The San Francisco Station was added in 1923 and the New Orleans Station in 1924. In addition, fifty-three other stations participated, some operated by State colleges of agriculture and State bureaus of markets, but the larger number by commercial agencies. Chain broadcasting was begun at Washington in 1929, Chicago in 1930, and San Francisco in 1931.

In 1926, the Congress provided a leased-wire extension to Iowa State College, whence reports were broadcast by the College station WOI, the College providing a market news editor and an

announcer. In Oklahoma, in coöperation with the Marketing Commission of the State Board of Agriculture and radio station KFJF, a loop of the leased wire was installed for market news service by radio. In 1928, a State Bureau of Markets was established in Tennessee and a coöperative radio program of market reports was begun at Nashville. At the same time, broadcasting from commercial stations in Philadelphia enabled the Delaware Bureau of Markets to present a more efficient service in that State. In the same year, coöperation with the Agricultural Extension Service of Colorado enabled the broadcasting of a special economic program from a commercial station in Denver. In 1929, a joint marketing program was begun with the Alabama Division of Marketing by remote control of a Birmingham station, and a joint program was carried in coöperation with State bureaus of markets in New England.

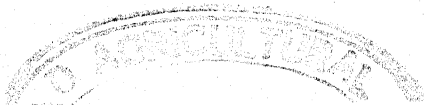
The publications listed in the Literature Cited at the end of this chapter which have been cited in these subsections on Historical Development and Special Marketing Studies in the section on Marketing Agricultural Products are Nos. 2, 3, 5, 7, 11, 16, 20, 31, 40, 41, 45, 47, 52, 57, 60, 61, 62, 63, 70, 85, 86, 87, 89, 90, 92, 94, 96, 98, 105, 108, 110, 112, 124, and 134.

COMMODITY MARKETING STUDIES

The foregoing section of Special Marketing Studies dealt mostly with marketing problems rather than with the actual marketing of commodities. The subsection on Coöperative Marketing Associations dealt with the marketing of certain commodities but only through producers' coöperative organizations. This section deals with studies of marketing commodities through ordinary commercial channels, except for those parts concerned with grades and standards and market news services, which apply to marketing by all agencies. For convenience, the material is separated into that concerned with general marketing and that dealing with groups of related commodities or with individual commodities.

General Marketing

From 1919 onward, several studies were made by Federal agencies in coöperation with State agencies on the general problems of marketing agricultural products. Some were specific marketing studies,



while others were portions of general economic surveys of agriculture or of some particular agricultural industry.

A study of the economic and legal aspects of compulsory proration in agricultural marketing in California, made at the request of the State Farm Bureau Federation and the State Chamber of Commerce, was published by the State Station (5—565) in 1933, with an acknowledgment of assistance received from the Federal Farm Board, the Federal Bureau of Agricultural Economics, and the State Farm Bureau Federation.

Many studies of production, marketing, and purchasing were conducted in other States in coöperation with Federal and intrastate agencies and occasionally some commercial organizations. Bulletins representing these coöperative studies were issued by Indiana (28—295), New Hampshire (54—222), New Jersey (55—416), New York (Cornell) (57—525, 585, and 586), Pennsylvania (66—185 and 198), Virginia (125—240), and Wisconsin (133—324). In Pennsylvania, the coöperation included the State Department of Agriculture, while in Virginia the Waterpower and Development Commission aided. The Wisconsin investigation included only the State Station and the State Department of Agriculture.

Grain Marketing

Official attention has been paid by Federal agencies to grain marketing for a full third of a century. At first, the studies were directed toward methods of determining quality, then to the factors influencing quality, and, finally, to the formulation of grades and standards. During the latter part of the period, handling and storage were investigated.

Corn and wheat are the primary grain crops moving in commerce, with lesser quantities of barley, flaxseed, grain sorghums, oats, rice, and rye. The greater number of the early investigations, both coöperative and independent, were devoted to corn and wheat, the other grains receiving attention at successively later dates, as marketing problems developed.

When the Congress authorized investigations of grain standardization in 1901, responsibility was placed in the Office of Botany of the Federal Bureau of Plant Industry. In about 1910, an Office of Grain Standardization was established in that Bureau. With

the creation of the Federal Office of Markets in 1913, some studies in this field were conducted coöperatively by the two Offices. On the passage of the U. S. Grain Standards Act in 1916, the two Offices were charged jointly with its enforcement (112—70). A year later, the Office of Grain Standardization was transferred from the Bureau of Plant Industry to the Bureau of Markets and later became a principal part of the present Grain Division of the Bureau of Agricultural Economics.

Grades and standardization.—Studies of grain standardization were begun officially on July 1, 1901, as a project in the Office of Botany of the newly created Bureau of Plant Industry. For several years, the work consisted principally of studying the commercial methods of inspecting and grading grain and of developing methods and apparatus for taking samples and determining quality. From 1906 onward, grain laboratories were established at Washington, D. C., and in important commercial centers.

Official standards for corn were promulgated in 1916, those for wheat were effective in 1917, and standards for oats, rye and grain sorghums were in effect by the end of 1925. Barley was added in 1926, and rice a year later. All inspection is by private inspectors, licensed by the Federal Department of Agriculture.

From 1901 to 1913, while the work was centered in the Bureau of Plant Industry, there was little coöperative activity. The Federal Bureau of Chemistry assisted by making moisture tests and developing apparatus for that purpose (110—41). Milling experiments on wheat were conducted by the Minnesota and North Dakota Stations for the Federal Bureau of Plant Industry and some grading was done by the Minnesota Grain Inspection Department (111—68). With the creation of the Federal Office of Markets in 1913, some coöperation developed between that Office and the Office of Grain Standardization, and joint contributions were published (86—516 and 574). Others concerned with wheat or corn will be mentioned later. In 1916, the two Offices were charged jointly with the administration of the U. S. Grain Standards Act of that year.

International coöperation was arranged with the government of the Dominion of Canada on the question of inspection of United States grain, moving in bond through Montreal to Europe. In 1930, under Senate Resolution 220, the Departments of State and Agri-

culture, the Interstate Commerce Commission, and the U. S. Shipping Board were authorized to investigate alleged diversions of grain shipments from United States to Canadian ports. Arrangements for a conference of the two governments were made and a satisfactory settlement reached (94—187).

Coöperative extension and other educational activities in connection with grain grading and standardization were begun in about 1918. Demonstrations of grain grading and apparatus were made at State and county fairs in nine States and at meetings of grain dealers' associations in twelve States. In coöperation with the Agricultural Colleges of Idaho, Iowa, Missouri, Ohio, Michigan, and Oregon, thirteen grain-grading schools were conducted for the training of inspectors. This type of extension activity was continued through the years as different grains were made subject to official standards, rice-grading schools being conducted coöperatively in the principal rice centers of Arkansas and Louisiana in 1926.

In 1930, an education committee, consisting of representatives of the Federal Grain Division, the agronomy departments of the State agricultural colleges, and the Federal-State Agricultural Extension Service, was formed to carry on a campaign of education on grain quality and grain grades. Grading schools were conducted in coöperation with the State agencies named, and a two-reel motion picture prepared. These activities have been continued.

Handling and storage.—Joint studies of grain elevators and systems of operating them have been made by Federal and State agencies from time to time. During the progress of the World War, the Bureau of Markets worked with the U. S. Food Administration Grain Corporation on effective storing of grain in concrete and steel bins.

During the period of the World War, the Federal Bureau of Markets coöperated extensively with the Bureaus of Plant Industry and Chemistry in a study of the farm cleaning of grain and its treatment against diseases, and the prevention of dust explosions and fires in grain separators in the Pacific Northwest. It coöperated also with the Bureau of Entomology in the control of insects in stored grain.

In 1918, assistance was given to the city of Portland, Oregon, in

the planning of a million-dollar municipal elevator. Several studies of elevators operated by farmers' cooperative associations were discussed in the preceding section. An extensive Federal-State study of the costs and efficiency of operating grain elevators in Kansas was made from 1921 onward, and the results jointly authored (31—246).

Extensive investigation of the possibility of handling grain in bulk and largely by machine methods in the Pacific Northwest was carried on by the Federal Bureau of Markets in cooperation with the Experiment Stations of Idaho, Oregon, and Washington, before and during the World War when labor was scarce and high priced (87—1290). Beginning in about 1927, another extensive investigation of the comparative costs of bulk handling and sack handling of grain on the Pacific Coast was undertaken by the Federal Division of Farm Management, in cooperation with the Experiment Stations of California and the three States named above. In California, the cooperation included the Station Division of Agricultural Engineering and the State Department of Agriculture also, and the study covered rice as well as other grains (90—161).

In about 1928, the Grain Division and the Division of Agricultural Engineering cooperated in a Federal study of farm grain storage and storage buildings (93—46). Two Federal Bureaus, Chemistry and Soils and Entomology, cooperated in developing an insecticide for use in stored grain, and, in 1930, the Federal Grain Division cooperated with them in determining methods for its commercial application.

Problems of storing grain of high moisture content resulted from the use of the combined harvester-thresher or combine for harvesting grain in the more humid eastern States. The Federal Grain Division and Division of Agricultural Engineering cooperated in experimental drying of grain in North Dakota (90—127) and rice in Arkansas and Texas (90—292). The Grain Division studied the respiration of sorghum grains in cooperation with the Kansas and Oklahoma Stations (89—100), and the harvesting and drying of rough rice with the California Station (5—541).

Wheat marketing.—From about 1909 onward, the Plant Industry Office of Grain Standardization cooperated with the North Dakota Station on the milling quality of wheat samples (86—328, 455,

478, 522, and 557). The last three also were joint contributions from the Bureau of Plant Industry and the Office of Markets and Rural Organization, as was also a fourth discussing nematode galls in market wheat (86—734), for which the U. S. Food Administration Grain Corporation assisted by collecting 3500 samples. One early study was coöperative both with the Minnesota and North Dakota Stations (111—68).

During the World War, the Bureau of Markets coöperated closely with the U. S. Food Administration and the War Trade Board on wheat marketing. In 1921 and 1922, the Division of Grain Standardization conducted an extensive campaign on wheat grades in coöperation with the Experiment Stations and Extension Divisions of the Dakotas. In 1928, a campaign for better cleaning of seed wheat and its treatment against fungus diseases was conducted by the Grain Division in California and Minnesota in coöperation with the State Experiment Stations and Extension Divisions and the Federal Office of Cereal Crops and Diseases (93—33).

From 1923 on, the Grain Division in Agricultural Economics and the Division of Cereal Investigations in Plant Industry coöperated extensively in determining the protein content of wheat samples (86—1183), and also in milling and baking tests of wheat varieties. In 1928, the Montana Station published on the marketing of high-protein wheat (47—213), acknowledging assistance from the Federal Grain Division, the Kansas Station, and the Minnesota Railroad and Warehouse Commission. In the same year, the Grain Division assisted the Experiment Stations of Delaware, Indiana, and Kansas in studying the milling and baking characteristics of wheat.

In 1930, when wheat prices were low, the Federal Bureaus of Agricultural Economics, Animal Industry, and Dairy Industry collaborated in a publication (94—96) on the economics of feeding wheat to livestock. The Grain Division also assisted the Grain Stabilization Corporation of the Federal Farm Board in determining the quality and condition of stored wheat and on grading appeals. Later it graded quantities of Corporation wheat for the American Red Cross and for delivery to the Government of Brazil.

Marketing of corn and other grains.—The Federal Bureau of Plant Industry began studies of corn quality and corn marketing

in 1901, receiving early assistance from the Bureau of Chemistry on moisture determination and apparatus (110—41). The Bureau of Markets coöperated on studies of keeping quality (86—764) during several years after 1910. In studying commercial sulphur bleaching of oats and barley, there was interoffice coöperation in the Bureau of Plant Industry (111—74). The Federal Bureaus of Markets and Agricultural Economics have assisted purchasing agents of the War Department, the Panama Canal Commission, and other Federal agencies from time to time in determining the quality of commercial oats. The Bureaus of Animal Industry and Plant Industry have coöperated in determining feeding values of light-weight barley, especially when infested with scab. International complications over scabby barley arose about 1927 and eventually entailed widespread coöperation of the two Bureaus named with the Bureau of Agricultural Economics, and with official agencies of the barley-producing States, as well as coöperation between the Federal Departments of Agriculture and State. From 1925 to 1928, the Bureaus of Agricultural Economics and Plant Industry coöperated in testing several hundred samples of flaxseed for oil content.

The mechanical and chemical effects of the milling process on rice were jointly studied and published by the Bureaus of Plant Industry and Chemistry in 1916. Following the adoption of permissive standards for rice in 1923 (91—291), the permissive grades for rough rice (91—290) were adopted by the California State Department of Agriculture and, some three years later, a rice-investigating office was opened by the Federal Grain Division in San Francisco in close coöperation with the California Department of Agriculture. In 1926, coöperative Federal-State rice-grading schools were conducted in Arkansas and Louisiana and, from 1929 onward, Federal-State rice-grading services were conducted in California, Louisiana, and Texas (96—1930:457). Under a formal agreement with the Texas State Department of Agriculture in 1929, a State inspector was licensed under the Food Products Inspection Act, in coöperation with the Federal Department. Since 1930, the Grain Division has graded numerous lots of milled rice for purchase by the War, Navy, and Interior Departments, and other Government agencies.

Cotton Marketing

Federal and State coöperation in the various phases of cotton marketing has been developing for more than a quarter of century. It has included the determination of market quality of newly introduced or improved cotton varieties, the formulation of grades and standards for the different kinds or classes of cotton, the handling of cotton for market, the relation of price to quality, the development of new uses for cotton, and extension activities in promoting effective cotton marketing.

Quality and standards.—The Bureau of Plant Industry coöperated at intervals for many years with the Office of Markets and its successors, the Bureau of Markets and the Cotton Division of the Bureau of Agricultural Economics, in determining the quality of new cotton varieties, especially by making spinning tests. In 1915, the two units studied the handling and marketing of Arizona-grown Egyptian (Pima) cotton (86—311), Plant Industry being represented by the Cotton Committee from four separate Offices. Further extensive tests were made in 1923–24. Spinning tests of Meade cotton were published (86—946) in 1921, the technical tests being made by the North Carolina College of Agriculture, and a general two-Bureau study of Meade cotton was published (86—1030) in 1922. This interbureau coöperation has been continued with an increasing number of State stations, the Cotton Production Council of the Association of Southern Agricultural Workers also coöperating and the South Carolina College of Agriculture conducting the spinning tests.

In 1918, the Bureaus of Plant Industry and Markets made a world survey of oil-producing materials and their products. The Bureaus of Plant Industry and Chemistry likewise coöperated in a study of the quality of cotton seed.

The formulation of cotton standards was authorized in 1908, investigations made by the Bureau of Plant Industry, and the first official standards promulgated in 1914 under the authority of the Cotton Futures Act. Manufacturing tests were conducted first by Plant Industry and then jointly with the Office of Markets in 1914 and 1915. This work was transferred to the Office of Markets in 1915 and tests of tensile strength thereafter were made coöperatively with the U. S. Bureau of Standards.

Spinning tests by the Bureau of Plant Industry and later by the Office of Markets were conducted in coöperation with Textile Departments of the North Carolina, South Carolina, and Mississippi Agricultural Colleges and the Lowell and New Bedford Textile Schools in Massachusetts (86—62). In later tests, coöperation was by North Carolina only (86—591, 946, and 990), with both North Carolina and South Carolina (86—1135), and with South Carolina alone (86—1148 and 1488). In 1928, the Texas Station assisted also in checking spinning tests.

The U. S. Cotton Standards Act of 1923 required the use of the official standards in the classification of cotton (91—278) and quotation of prices in interstate and foreign commerce. At an international conference promptly held in Washington, D. C., it was agreed that the U. S. Standards for grade and color of American cotton should be universally adopted. Four similar international conferences have been held since, the last in 1932.

With the development of standards and grades for cotton as an aid to effective marketing, it became necessary to train large numbers of persons in their use. By 1914, the Texas Legislature required that counties having 10 per cent or more of their land in cotton production should purchase sets of the cotton-grade samples for the use of the County Superintendent of Schools in teaching cotton grading.

The Federal Bureau of Markets and the States Relations Service coöperated in 1917 in preparing 125 sets of samples of cotton standards for distribution to southern county demonstration agents. Demonstrations were held at the four District Agricultural Schools in Arkansas and, in 1919, coöperative demonstrations were made in Arkansas, North Carolina, South Carolina, and Texas. This work was continued and, after the passage of the Cotton Standards Act in 1923, was greatly extended in coöperation with the colleges of agriculture in the cotton belt. All persons obtaining licenses to classify cotton under the Cotton Standards or Warehouse Acts were required to pass a standard test made possible by attending courses at the coöperative Federal-State Classing Schools held at the various State agricultural colleges.

Handling cotton for market.—From 1913 to 1915, the Bureau of Plant Industry and Office of Markets coöperated on the handling

and marketing of Arizona-grown Egyptian cotton (86—311) and on Imperial Valley cotton in California. The Bureau of Markets, the Federal Horticultural Board, and several State agricultural colleges coöperated to determine the effect of fumigating baled cotton on fiber quality (86—366). From 1914 onward the Office and Bureau of Markets coöperated with officials of Arkansas, North Carolina, South Carolina, and Texas in a comprehensive survey of cotton-marketing conditions, especially cotton warehouses and warehouse legislation. The warehouse inquiry was conducted in other States through questionnaires filled by county agricultural agents (86—216) and by conference with State officials. On completion of the North Carolina study (86—476), the State legislature authorized county commissioners in that State to employ county cotton classers in coöperation with the State Station and/or the Federal Bureau of Markets.

During the World War, the Bureau of Markets coöperated with the War Industries Board, the U. S. Shipping Board, and the U. S. Railroad Administration in cotton-storage and transportation problems, especially high-density compression.

As ginning practices affect the market quality of cotton, the Federal Division of Cotton Marketing conducted extensive studies from 1925 onward with the North Carolina College of Agriculture on the costs and practices of operating gins. An experimental gin was built at the Delta Branch Station of the Mississippi Experiment Station by the Federal Division of Agricultural Engineering and the Division of Cotton Marketing, in full coöperation with the State. These two Federal Divisions, together with the Plant Industry Division of Cotton Investigations, also studied the use of roller gins on long-staple cotton in Arizona.

Beginning in 1925, the Federal Division of Cotton Marketing coöperated widely with the State experiment stations in a study of cotton marketing. The Arkansas (3—245) and South Carolina (69—270) studies covered the status of coöperative marketing. Cotton quality was investigated in Georgia (22—157) and Mississippi (42—300), and home markets in North Carolina (58—284).

From about 1925 onward, the Federal Division of Cotton Marketing coöperated with State experiment stations in a far-reaching

study of the prices received by cotton growers in relation to quality as expressed by grade and staple length. This resulted in numerous coöperative station publications in Alabama (1—235), Georgia (22—165 and 174), Louisiana (33—221), Mississippi (44—21), Oklahoma (62—212), South Carolina (69—279 and 290), and Texas (73—383).

New uses for cotton.—During the World War, the Federal Bureau of Markets, in coöperation with the Signal Corps of the United States Army, made a considerable study of cotton fabrics suitable for airplanes and balloon construction (86—882). Assistance was rendered also by the Bureau of Plant Industry and the Bureau of Standards. Beginning in 1927 and specially authorized by Congress in 1928, the Division of Cotton Marketing began coöperation with the Federal Bureau of Home Economics and the Department of Commerce, with numerous State agencies, especially in the Carolinas and Texas, and with commercial organizations, on possible new uses for cotton. The Bureau of Bedding in the Pennsylvania State Department of Labor and Industry assisted by testing cotton in mattress manufacture. A bibliography on cotton uses (99—44) was issued in 1932.

Tobacco Marketing

In Virginia, a coöperative study of marketing tobacco was made by the State Experiment Station (125—285) and the Tobacco Division of the Federal Bureau of Agricultural Economics. A Connecticut study was coöperative between the Experiment Station and Extension Division of the Storrs Agricultural College (12—134).

Under the Tobacco Stocks and Standards Act of 1929, there was begun also a tobacco-grading service, conducted in coöperation with the State experiment stations. Coöperative agreements were made in 1930 with Kentucky, North Carolina, South Carolina, Tennessee, and Virginia. A short course in tobacco sorting and grading was held in 1930, in coöperation with the North Carolina Agricultural College, with assistance from officers of that and nearby States. By 1933, the legislatures of Maryland and Virginia had enacted laws making grading of tobacco compulsory, and a coöperative agreement for Maryland also was in progress.

In 1932, studies of Federal Division of Tobacco Marketing on weight losses in tobacco from harvest to manufacture, were made

available for use by the Bureau of Internal Revenue of the Treasury Department in making regulations, and by the Agricultural Adjustment Administration in assessing the tobacco-processing tax. A bibliography on the coöperative marketing of tobacco was published (99—13) by the Federal Bureau of Agricultural Economics in 1926.

Marketing Maple-Sap Products

A study of marketing maple-sap products, coöperative between the Federal Bureau of Markets and the Vermont Extension Service, was published (124—227) in 1922 by the Vermont Station, under Federal authorship.

Marketing Hay, Feed, Seed, and Broomcorn

These commodities are combined under one heading for several reasons. All of them are handled by the Hay, Feed, and Seed Division of the Federal Bureau of Agricultural Economics. The distinction between hay and feed is not sharply drawn, alfalfa hay becoming a feedstuff when ground into alfalfa meal. Broomcorn logically does not belong to any of these groups but is really a fiber crop. From the standpoint of marketing, however, it is entirely unrelated to cotton, the principal American plant fiber.

Hay marketing.—The subject of hay marketing comprises hay quality and handling, grades and standards, extension activities, and market news service.

Investigations of the quality and marketing of hay were begun by the Office of Farm Management of the Federal Bureau of Plant Industry in about 1910.

The Hay, Feed, and Seed Division, in 1922, coöperated with the New York State Department of Agriculture in making plans for the improvement of hay-marketing conditions in New York City, and with the Federal War Department in drafting regulations for weighing hay in New York markets.

With the promulgation of the first tentative standards and Federal grades for certain hays in November, 1922, extensive field studies of the kinds and qualities of hay became necessary. By 1925, the Federal Bureau of Agricultural Economics reported that coöperative agreements covering field and marketing studies of hay had been made with the State Agricultural Colleges of Alabama,

Arkansas, Kansas, Minnesota, Nebraska, Oklahoma, Oregon, New York, and Texas. This coöperation covered quality and handling, and the determination of grades and standards.

In 1930, the Nebraska Experiment Station coöperated with the Federal Division of Forage Crops and Diseases and the Division of Hay, Feed, and Seed in a study of the quality of alfalfa hay (89—235), with assistance in protein determination from the Station Division of Chemistry.

During 1927 and 1928, the Federal Divisions of Hay, Feed, and Seed, and of Farm Management and Costs coöperated with the Experiment Stations of California, Colorado, Idaho, Minnesota, Montana, Nebraska, Nevada, Oregon, South Dakota, and Utah, on the measurement of hay in stacks and mows as a basis for developing an adequate formula (89—239; 96—1931:283—85). The statements of coöperation were given on the outside and inside of the front cover, and a list of coöperating stations on the title page. The California Station published the data (5—570) in 1934, with cover and text statements of coöperation.

In 1927, the Division of Animal Husbandry in the Federal Bureau of Animal Industry, the Hay, Feed, and Seed Division, and the Quartermaster Corps of the U. S. Army entered into a co-operative agreement to conduct extensive feeding experiments on the relative value of different kinds and grades of hay. The War Department furnished the funds for buying feed, and cavalry and artillery horses were used for the experiments, which were continued through 1929.

Tentative standards for Federal grades of certain grass and clover hays were issued in 1922, final permissive standards (91—326) became effective in February, 1924, and Federal inspection of hay began in seven major markets in January, 1923. A strong demand developed among State Marketing Departments and commercial agencies for grades and standards for alfalfa, Johnson grass, and wild grass hays. Coöperative branch laboratories were established at the Experiment Stations of Alabama and Minnesota for a study of these three hays, looking toward the formulation of standards. Standards for grain hay were formulated, beginning in 1925, in coöperation with the Oregon Agricultural College. By 1925, it was reported that the Federal standards had been adopted

as official standards also by eleven States (Alabama, Idaho, Kansas, Maine, Maryland, New Jersey, North Carolina, Oklahoma, Utah, Virginia, and Wisconsin) and were under consideration in ten other States (98—1925:38). In the next year, six of these took similar action, making a total of seventeen. At the same time, thirty-nine State agricultural colleges were using the United States hay standards in teaching hay grading and other subjects.

The Federal Specifications Board for Government Purchases required that the Federal hay standards, as adopted, be used in all government purchases. In January, 1926, a conference of representatives of all Federal Departments interested in the purchase of hay was held in order to explain the standards and offer an inspection service. In 1927, after conferences between the Division of Hay, Feed, and Seed, and representatives of the Army Veterinary Corps and Quartermaster Corps, together with the California State Department of Agriculture, new specifications for grain hay were prepared. The hay standards and the inspection system were discussed by the coöperating California Department (7—17:606) in 1928.

By 1928, Federal-State coöperative hay inspection was carried on under agreements in six States. Army veterinary officers licensed as Federal inspectors were stationed also at twenty-six posts of the United States Army. In 1930, six new coöperative agreements for hay-inspection service were signed, especially for the alfalfa sections of the West, including coöperation with the California State Department of Agriculture.

In connection with the formulation of grades and the beginning of Federal inspection in January, 1923, it became necessary for the Federal Division of Hay, Feed, and Seed to train hay inspectors. The first training school was held in 1924, and included members of the Alabama Extension Service, the U. S. Quartermaster Corps, and the Army Veterinary School at Washington, D. C. The second school was held later in the same year, with representatives in attendance from several other agricultural colleges and from the Canadian Department of Agriculture. The officers from the Army Veterinary School, after training, were licensed as Federal hay inspectors in making purchases of hay for the War Department. In 1926, seven schools were held, attended by representatives

of the State departments of agriculture, State agricultural colleges, United States Army, and commercial organizations.

Hay-grading demonstrations were conducted in 1926 by the Federal-State Extension Services in several States, especially Alabama, Arizona, Kansas, Nebraska, and New Mexico. In 1928, the same agencies coöperated in several States in demonstrating the best methods for handling alfalfa to produce quality hay. State departments of agriculture also aided in these demonstrations. Hay-judging contests were held in coöperation with the International Livestock Show in Chicago and with several of the State agricultural colleges.

Feed Marketing.—Relatively little has been done in this field. In 1924, the Market News Service was extended to cover feed prices, which were transmitted over Department leased wires and printed or mimeographed and distributed by State agencies. New Jersey was the first State to coöperate, followed by New York, Pennsylvania, and the New England States. A branch office was established at Minneapolis, covering adjacent States.

Alfalfa meal having become important as a livestock feed, the State Departments of Agriculture in Idaho, Nevada, and Utah desired the Federal Division of Hay, Feed, and Seed to formulate standards for it and institute an inspection service. Extensive studies of the problems involved were made from 1927 to 1933, inclusive, partly in coöperation with interested States and the Association of Feed Control Officials.

Seed marketing.—During 1927 and 1928, the Federal Division of Hay, Feed, and Seed assisted the American Red Cross on seed stocks needed for relief of the sufferers from the Mississippi flood. In 1930 similar aid was given to the Red Cross in the purchase of vegetable seeds for areas where severe drought had prevailed.

In 1934, the Illinois Station published (26—404) on the production and marketing of redtop seed. This was a joint contribution of the Station Departments of Agronomy and Agricultural Economics, with acknowledgment of assistance from the Illinois Federal-State Crop Reporting Service, the State Department of Agriculture, and the Federal Bureaus of Agricultural Economics and the Census, as well as commercial agencies.

Recommended Federal standards for navy beans were published

in 1926, and were adopted as official State standards by Idaho, Montana, and Wyoming, where a joint Federal-State inspection service was inaugurated by the Division of Hay, Feed, and Seed in 1927. Similar action was taken in California, Colorado, Georgia, Texas, and Utah. In coöperation with the California State Department of Agriculture, bean inspection was extended to shipping points in 1930 and a special survey of problems of production and market preparation was made coöperatively in 1931.

Beginning in 1926, the Federal Division of Hay, Feed, and Seed coöperated with the Navy Department on problems affecting the quality of navy beans in storage, including the operation of the Brown-Duvel moisture tester in determining storage quality (86—1375). Inspections by the Division for the Navy Department and the Marine Corps have steadily increased in volume.

After adoption of Federal standards for soybeans in 1926, five inspectors were licensed, three of whom worked in coöperation with the North Carolina State Department of Agriculture. In 1931, some 500,000 bushels of soybeans were inspected in Illinois storage on the request of the Federal Intermediate Credit Bank of St. Louis.

In 1928, a study of the effects on the quality of soybeans produced by harvesting with the combined harvester-thresher and with grain-binders was made in coöperation with the Illinois and Indiana Stations by the Federal Divisions of Farm Management and Costs, Cereal Crops and Diseases, and Agricultural Engineering. The resulting publication (89—244), under three-Division authorship, showed the coöperation prominently on and inside the cover, and on the title page.

The U. S. Seed Import Act requires the geographic origin of certain imported seeds to be certified by the importers. Enforcement is by the Division of Seed Investigations of the Bureau of Plant Industry. This Division and the Division of Hay, Feed, and Seed, either independently or in coöperation with State agencies, conduct investigations in this field.

Broomcorn marketing.—Tentative Federal standards for broomcorn brush were adopted as the official standards for Oklahoma, and a joint Federal-State inspection service established in 1925, in coöperation with the Oklahoma State Marketing Commission.

Training schools for inspectors and demonstrations of standards were held in Oklahoma thereafter in coöperation with the Commission. In 1929, a market-news service on broomcorn was begun in Oklahoma with the same coöperation.

Fruit, Nut, and Truck-Crop Marketing

In this field, perhaps more than any other, there is no clear division between the special production surveys and farm-management studies of fruit and nut crops, already discussed, and the marketing studies which are properly the subject of this section. Several of these inquiries have covered all three of these aspects of the problem, and many of them have covered at least two.

The same Federal Division is concerned with both fruits and vegetables, and, for this reason, there is presented first a brief discussion of marketing activities concerned with both groups of commodities, although the two are treated separately thereafter.

There has been a steadily increasing coöperation between Federal and State agencies in respect of fruit and truck-crop marketing for more than twenty-five years. Investigations were conducted by the Federal Bureau of Plant Industry up to 1913, by this Bureau and the Office (later Bureau) of Markets independently or co-operatively to 1922, and thereafter by the Division of Fruits and Vegetables in the Bureau of Agricultural Economics. State agencies involved include the State colleges of agriculture through their experiment station and extension divisions, the State departments of agriculture, and the State marketing units (if separate from the department of agriculture).

Transportation and handling.—The Federal Bureau of Plant Industry began studies of transportation problems in fruit and vegetable handling about twenty-five years ago, at first entailing only minor coöperation with the Federal Bureau of Chemistry and other units. After 1913, there was coöperation with the Federal Office of Markets on problems of transportation and storage, illustrated by a joint contribution on the handling and pre-cooling of Florida lettuce and celery (86—601).

In 1918, the Bureau of Markets continued studies of the efficiency of refrigerator cars and the best methods of constructing heater cars, in coöperation with the U. S. Railroad Administration,

and the approved types of car adopted as standard by that Administration. In 1919 and 1920, the two agencies again coöperated in a survey of railway icing stations in the east-central States and effected economies of operation.

In 1926, the Federal Bureaus of Plant Industry and Agricultural Economics published two comprehensive summaries on the origin and development of the fruit and vegetable industry (96—1925: 107) and the marketing of fruits and vegetables (96—1925: 623).

In 1923, the Bureau of Plant Industry began coöperation with the Division of Agricultural Engineering in studies of pre-cooling before shipment and of refrigeration during transportation, and in 1925 a portable plant was designed for the Bureau by the engineers. In California, the Divisions of Pomology and Agricultural Engineering at the Experiment Station coöperated with the California Committee on the Relation of Electricity to Agriculture in a State study on the pre-cooling of fresh fruits, and on proper temperatures of refrigerator cars and warehouse rooms (5—496).

From 1924 to 1926, the Federal Bureau and Division continued coöperation in a study of body icing and ordinary icing in comparable refrigerator cars, the Interstate Commerce Commission aiding in the study. From 1928 to 1932, these two agencies coöperated in studies of the heating and ventilating of cars carrying winter shipments from the Pacific Northwest to eastern markets.

During 1923 and 1924, the Federal Division of Fruits and Vegetables made an extensive study (86—1411) of the marketing of fruits and vegetables in New York City, in coöperation with the Port of New York Authority and the New Jersey Experiment Station. A study of retail margins on fruits and vegetables was conducted in Trenton, New Jersey, in coöperation with the State Department of Markets. A study of the motor truck in transporting fruits and vegetables to greater New York, a coöperative enterprise of the Federal Divisions, the New Jersey Station (55—503) and the New Jersey Department of Agriculture, was published in 1930, with a cover statement of coöperation and assistance acknowledged from the Port Authority, the (New York) City Department of Public Markets, and the New York Food Marketing Research Council.

Grades, standards, and inspection.—The Federal Bureau of Markets, both independently and in coöperation with official marketing agencies and commercial organizations, made extensive studies of the container problem. As a result, the U. S. Standard Container Act was approved in 1916, effective in 1917 (112—76). In 1920, the Bureau, in coöperation with the marketing officials of the various States, made a study of legislation governing the standardization of containers.

The Federal Bureau of Markets and its successor, the Division of Fruits and Vegetables, gradually developed standards for the more important fruit and vegetable crops. By 1926, grades had been recommended for thirty-five different fruit and vegetable commodities. About thirty States had officially adopted the grades for one or more of these commodities. In many cases, the use of the grades was compulsory for all crops standardized under State laws.

A very large part of the market inspection, especially in the early years, was devoted to fruits and vegetables. The Bureaus of Markets and Plant Industry coöperated from 1919 onward in training market inspectors to identify diseases, and in preparing colored plates by which such diseases might be recognized. In 1932, the Bureau of Plant Industry and the University of Chicago began a joint revision and elaboration of an earlier study of market diseases of potatoes (94—98), tomatoes, peppers, and eggplants (94—121) and other vegetables.

Under a coöperative agreement between the Federal Bureau of Agricultural Economics and the California State Department of Agriculture, the chief of the Federal Division of Fruits and Vegetables became chief of the California Division of Markets in 1927. The Federal Bureau of Agricultural Economics was charged with the enforcement of the Produce Agency Act of 1927 and its successor, the Perishable Agricultural Commodities Act of 1930, directed especially at dishonest practices in the fruit and vegetable trade. State agencies render assistance in providing information on specific cases.

Increasing quantities of fruits and vegetables are inspected for the Navy Department, the U. S. Marine Corps, and the U. S. Shipping Board, substantial savings being effected. Inspections for the

Navy Department began at New York City during the World War, soon afterward at the Great Lakes Naval Training Station, and thereafter at several other naval bases.

Fruit and nut marketing.—Some data on the marketing of fruits and nuts have been discussed under general marketing at the beginning of this section. The coöperative New York studies concerned with perishable agricultural products (57—525, 585, and 586) dealt largely with fruits.

Foreign markets for fruits: In June, 1917, a representative of the Federal Bureau of Markets investigated Oriental markets for fresh, dried, and canned fruit. Coöperation was obtained from the representatives of the Consular Service of the Department of State and the Bureau of Foreign and Domestic Commerce in the Department of Commerce. By arrangement with the Department of State also, cable reports were received covering shipments of Italian lemons to the United States. In 1927, a marketing specialist in fruits and vegetables made an extensive survey of European markets, with coöperation from the Federal Departments mentioned above.

In 1930, the California Station published the results of a far-reaching investigation (366 pp.) of fruit markets in eastern Asia (5—493). The authors, from the Extension Division of the University of California, were under appointment by the trade commissioner of the U. S. Department of Commerce during this coöperative investigation. They acknowledged ample assistance received from trade commissioners of that Department, and from the consular officers of the Department of State in the Orient, as well as from officials of universities and colleges and from commercial organizations.

Apples: The Federal Bureau of Plant Industry, through its Office of Horticulture and Pomology Investigations, began studies of the handling and storing of apples in about 1911. After 1913, these studies usually were conducted in coöperation with the Federal Office of Markets. Resulting publications, covering one early (86—587) and two later studies (86—1406 and 1415), represent extensive Federal interdivisional and Federal-State coöperation which prevailed over a long period of years.

In 1926, the Federal Division of Fruits and Vegetables began

a national survey of the apple industry, in coöperation with the experiment stations and extension divisions in many States. The data obtained covered distribution, prices, sales methods, and selling costs. This study was made in connection with the general horticultural, farm-management, and statistical studies of the apple industry in which other Divisions of the Bureau of Agricultural Economics and the State agencies were primarily interested. Several resulting State publications have been discussed already under Special Production Surveys. The Federal Bureau of Agricultural Economics published, in 1927, a bibliography on the economic aspects of the apple industry (99—19).

The survey in California of the economic aspects of the apple industry was made under a coöperative agreement between the California Station and the Federal Bureau of Agricultural Economics, covering both planning and financing (5—445). Besides the Federal Division of Fruits and Vegetables, assistance was obtained from the Federal-State Crop Reporting Service and the Bureau of Standardization of the State Department of Agriculture.

A comprehensive study of marketing California apples, published by the State Station (5—501) in 1930, under joint authorship of the Divisions of Agricultural Economics and Pomology, acknowledged assistance from the Federal-State Market News Services in California and Washington, the Division of Markets of the State Department of Agriculture, the Federal Bureau of Foreign and Domestic Commerce, the county farm advisors in Santa Cruz and Sonoma Counties, and many commercial agencies.

The recent Delaware study on the marketing of early apples (13—185) was coöperative only between the State Experiment Station and the State Bureau of Markets. In Indiana, a study of Indianapolis apple markets (28—322) was jointly authored by the Indiana Station Department of Horticulture and the Federal Division of Fruits and Vegetables.

A coöperative study of marketing apples in the Cumberland-Shenandoah region of Pennsylvania, Virginia, and West Virginia, begun in 1924, was jointly authored by the Federal Division of Farm Management and Costs and the three State Colleges of Agriculture. The resulting publication (89—234) gave a prominent

statement of the coöperation involved. In 1922, the Federal Division of Farm Management and Costs entered into coöperation with the Agricultural Experiment Stations of Idaho (24—162), Oregon (63—244), and Washington (128—242), in studies of prices, quality, destination, and cost-of-marketing services for apples.

Pears: A coöperative study of the handling of Bartlett pears from Pacific Coast districts was made in 1925 and 1926 by the Federal Office of Horticultural Crops and Diseases and the California Station Division of Pomology, and published under joint authorship by the Federal agency (89—140) in 1929. An economic study of the pear industry of California, made in 1926 and 1927 by the California Division of Agricultural Economics (5—452) with commercial coöperation acknowledged assistance from three Divisions of the Federal Bureau of Agricultural Economics, the Bureaus of the Census and Foreign and Domestic Commerce in the U. S. Department of Commerce, the Interstate Commerce Commission, many county horticultural commissioners in California, and the Oregon and Washington State Agricultural Colleges.

Peaches and apricots: A special survey of the fresh peach industry, covering horticultural, statistical, and production-costs data, coöperative between several Divisions of the Federal Bureau of Agricultural Economics and official agencies in peach-growing States, was discussed previously under Special Production Surveys. This survey also covered studies of consumption, competition, prices, and marketing in twenty-six States, a general report was issued, and separate reports published by ten of the States. Later extensions of the marketing studies were made in certain States. In 1925, the Federal Bureau of Agricultural Economics published a bibliography on the economic aspects of the peach industry (99—8).

In Georgia, the State Agricultural Experiment Station, an institution separate from the Georgia State College of Agriculture, coöperated with the latter on the marketing of Georgia peaches, later published by the Station (22—155). In New Jersey, the Experiment Station, the Extension Service, and the State Department of Agriculture coöperated on practices in peach production and marketing (55—477). The New Jersey Station and the Federal

Division of Fruits and Vegetables coöperated in a study of factors affecting the price of peaches from New Jersey and the Southern States in the New York City market (89—115).

In California, an economic study covering supply, demand, and prices of California peaches (5—547) and a similar study on apricots (5—423) were made by the Experiment Station, with assistance from the Federal-State Crop Reporting Service, the Divisions of Fruits and Vegetables and Foreign Agricultural Service of the Federal Bureau of Agricultural Economics, and the Bureau of Foreign and Domestic Commerce of the Federal Department of Commerce.

Prunes and cherries: In California, a study of the prune supply and price situation was published by the State Station (5—462) in 1928, with acknowledgment of assistance from the Federal Divisions of Fruits and Vegetables and Statistical and Historical Research, and also from the Division of Markets of the California State Department of Agriculture.

In Oregon, the Experiment Station and Extension Service coöperated with the Federal Divisions of Fruits and Vegetables and Agricultural Coöperation in an economic study of the prune industry of Oregon and Washington.

An economic and marketing study of the cherry industry of California in 1930 covered coöperation by the University of California Division of Agricultural Economics (5—488), the Federal agencies mentioned in the study of prunes, and assistance also from the Oregon and Washington Agricultural Colleges.

Citrus and other fruits: Several coöperative economic studies of the citrus-fruit industry of California have included material on the marketing problems of oranges (5—457), lemons (5—460), and grapefruit (5—463), published in 1928. The Federal-State coöperation was the same as that mentioned under peaches, with occasionally some other agencies.

An economic study of olives in California similar to that for cherries included some market data and covered the coöperation of the State Experiment Station and Extension Service with the same Federal agencies. A discussion of the sales methods and policies of the calavo growers of California, published by the California Station (5—539) in 1932, acknowledged much assistance from

county farm advisors in four southern counties, and from the Federal-State Market News Service in Los Angeles.

Grapes and raisins: In California, an economic study of the grape industry, including shipments, prices, markets, etc., (5—429) had the same coöperation and assistance from numerous agencies as the similar study of the pear industry, except that no other States participated. An extensive study of foreign-production trade, in the raisin and currant industry, was conducted co-operatively by the California Station (5—566) and the Division of Foreign Agricultural Service, with acknowledgment of assistance from representatives of the Federal Departments of Agriculture, Commerce, and State in foreign countries, and from similar officials of foreign governments, as well as from various Federal and State libraries, including that of the city of San Francisco.

A California study of conditions affecting annual prices of fresh grapes (23—6:101), and a similar study of the conditions affecting raisin sales and prices (23—6:73), made by the California Experiment Station, acknowledged coöperation of the Federal Farm Board, the Federal Bureaus of Agricultural Economics and Foreign and Domestic Commerce, and the California State Department of Agriculture. Statistics of the California grape distribution for 1928 and 1929 were compiled coöperatively by the State Department and the Federal Economics Bureau.

Studies of the growing and marketing of grapes were made in 1929 by the Federal Division of Farm Management and Costs in coöperation with the Experiment Stations of Arkansas, Missouri, New York (Cornell), and the State Colleges of Michigan and Pennsylvania (66—260). In 1932, the Federal Bureau of Agricultural Economics published a bibliography on the economic aspects of the grape industry (99—36).

Small fruits: Studies of cranberries, raspberries, and strawberries are included. Cranberry harvesting and handling was investigated by the Federal Office of Horticultural Crops and Diseases, in coöperation with the Massachusetts and Wisconsin Stations and published (87—1402) in 1924 under joint authorship of the three institutions. In Minnesota, the Station Divisions of Agricultural Economics and Horticulture coöperated in a study of marketing locally grown raspberries (40—245).

In 1924, the Federal Division of Farm Management and Costs coöperated with the North Carolina State Bureau of Markets and State College of Agriculture in a survey of strawberry production and marketing. Later this Federal Division began a general study of the strawberry industry in coöperation with ten southern and eastern States. The chief marketing feature was competing areas, but in Arkansas it included market preferences and prices with reference to the New York City market. The Federal Bureau of Agricultural Economics published in 1929 a bibliography on the economic aspects of the strawberry industry (99—28).

Nuts: In California, recently, an economic survey of the almond industry (5—453) and a similar study of walnuts (5—475), made by extension specialists of the University of California Division of Agricultural Economics, acknowledged assistance from different Divisions of the Federal Bureau of Agricultural Economics, the Bureau of Foreign and Domestic Commerce, and county farm advisors, and the latter also from the Federal Interstate Commerce Commission. Previously, the Federal Division of Fruits and Vegetables had coöperated with the California State Department of Agriculture on walnut grading.

In 1928, a general survey of the pecan industry was conducted by Divisions of the Federal Bureau of Agricultural Economics in coöperation with the experiment stations and extension divisions of the southern States concerned.

Truck-crop marketing.—The Federal Bureau of Markets carried forward the preliminary studies of vegetable marketing which the Bureau of Plant Industry had begun. A popular discussion of why produce inspection pays was published (96—1919:319) in 1920. Early attention was given to proposed grades for different truck crops (91—95, 96, 97, 99, 238, and 304).

Coöperative arrangements were made with the California State Department of Agriculture in 1920 for specialists to engage in a study of grades and standards for California truck-crop products and their containers (105—1920:546). Studies made later in coöperation with other States included market demand for vegetables in Connecticut (12—138), interstate and foreign competition with truck crops in Florida (20—224), and, in New Jersey, an extensive compilation of New York market prices for New Jersey vegetables,

covering data for the years 1910 to 1933, inclusive (55—575), made possible through financial assistance from the Federal Civil Works Administration.

Potatoes: In 1917, on request of the Federal Reserve Board, the Bureau of Markets, in conjunction with the U. S. Food Administration, published recommended grades for potatoes (106—7) with the various cooperating agencies indicated in the title. On the basis of these grades, loans were made by member banks in the Federal Reserve System against warehouse receipts. The use of these grades was made compulsory on the licensees of the U. S. Food Administration in January, 1918. Several States made their use compulsory under State legislation. Recommended grades were published by the Federal Bureau (91—96) in 1920 and again (91—238) in 1922.

Federal-State collaborative studies from 1921 to 1925 included local cooperative potato marketing (40—195), and local potato-warehouse organization in Minnesota (41—28), the latter by the Federal Division of Warehousing; an economic study of marketing potatoes in New York (57—440); and a study of the marketing of Maine potatoes, made by this same Division at the request of the Federal Farm Loan Board, to determine the possibility of warehouse receipts as collateral for loans.

A recent intrastate study of the effect of handling methods on the quality of Maine potatoes was conducted by the Maine Development Commission and the State Experiment Station (34—365), in cooperation with the Maine Extension Service and the State Department of Agriculture.

Other vegetables: The California Station in 1932 published on the marketing of globe artichokes (5—524), acknowledging assistance from the Federal-State Market News Service, the agricultural commissioners of Monterey and San Luis Obispo Counties, and the county farm advisors of Marin, Monterey, and Santa Cruz Counties.

The New York (Cornell) Station in 1925 published on the marketing of cabbage (57—443), acknowledging much information from the Federal Division of Fruits and Vegetables. In 1924, that Division also published on the marketing of cabbage (86—1242), with acknowledgments of assistance from the Federal Bureau of

Plant Industry and from four other Divisions of the Bureau of Agricultural Economics, namely, Agricultural Coöperation, Agricultural Finance, Cost of Marketing, and Statistical and Historical Research.

The growing, handling, and marketing of California celery was discussed by the Bureau of Standardization of the California State Department of Agriculture (7—12:73; 8—36) in 1923, much of the historical data contained being contributed by the Federal Bureau of Markets. A later discussion (7—20:331) in 1931 was a product of the Federal-State Shipping Point Inspection Service.

In 1925, the Federal Division of Fruits and Vegetables published on the marketing of onions (86—1325) with acknowledgment of assistance from the Bureau of Plant Industry and other Divisions of its own Bureau.

In 1927, the Division of Fruits and Vegetables began coöperation in Delaware, Indiana (28—328 and 350), New York, and in 1930 in Ohio (61—504), on the marketing of tomatoes at canneries, with special reference to inspection and buying on grades. In Delaware, the coöperation was with the State Bureau of Markets.

Melons: In 1916, the Transportation Section of the Federal Office of Markets and Rural Organization, in coöperation with the Bureaus of Chemistry and Plant Industry, made a study of watermelon losses in transportation and storage. In the same year the Office of Markets and Rural Organization published independently on the commercial grading, packing, and shipping of cantaloupes (87—707), and in 1921 on handling and transportation (87—1145). The California Station in 1927 published on the economic aspects of the cantaloupe industry (5—419), including marketing, and acknowledged assistance from the Federal Division of Fruits and Vegetables, both in California and in New York City, the latter coöperation representing the Port of New York Authority also.

The Colorado Station (11—312) studied the harvesting and marketing of cantaloupes and honeydew melons in 1924 and 1925, in coöperation with the Federal Division of Fruits and Vegetables and the Colorado Office of Markets. A Michigan study (37—193) of cantaloupe production acknowledged marketing information from the Chicago Office of the Federal Market News Service, and

the use of chemical laboratories from the school authorities of Benton Harbor.

Livestock and Product Marketing

Livestock and their products, as discussed here, do not include poultry and eggs, or honey. These are treated in separate subsections.

Little attention to live-stock marketing problems has been given by the Federal Bureau of Animal Industry.

In November, 1915, after the creation of the Federal Office of Markets, a conference of official and commercial agencies was held in Chicago to promote more stable market conditions and more efficient methods. The results were published (77) by the U. S. Congress. Following the conference, the Office made an extensive compilation of material on the meat situation in the United States, and published the data in a series of five reports (95—109, 110, 111, 112, and 113) in 1916. Assistance was acknowledged from the Bureaus of Crop Estimates and Animal Industry, and the Office of Farm Management. The fifth report (95—113) was devoted to methods and costs of marketing livestock and meats. During 1916 and 1917, the Office of Markets and Rural Organization conducted a study of municipal abattoirs and of private abattoirs municipally inspected, with assistance from the officials of various municipalities. In 1919, the Bureaus of Markets and Animal Industry co-operated in a study of the condition of country hides (87—1055).

Wartime coöperation.—In 1918, by direction of the President, the Federal Bureau of Markets and the Federal Trade Commission conducted a coöperative investigation of the meat supply and related questions. The Bureau also made a study of the supply and prices of casein for the Aircraft Construction Division of the Navy Department and the Federal War Trade Board. In 1919, the Bureau made arrangements with the U. S. Shipping Board for the transportation of dairy cattle to France, and also assisted the relief commission in estimating food conditions in Central Europe.

In 1918, type samples of the commercial grades of wool were prepared by the Bureau for the use of the Quartermaster Division of the War Department. Thereafter, coöperation in the grading and

marketing of wool was maintained with the Departments of Navy and War, the Council of National Defense, the U. S. Shipping Board, the Federal Tariff Commission, the War Industries Board, and the War Trade Board.

Grades and standards.—Investigations in the grading of livestock and meats were begun actively in about 1920, although preliminary studies had been made in earlier years. For the most part, studies were conducted independently by the Federal Bureau of Markets, but there was some coöperation with official State marketing agencies.

In about 1925, the Division of Livestock, Meats, and Wool began an extensive determination of the factors of quality and palatability of meats, in coöperation with the Bureaus of Animal Industry and Home Economics and State agricultural colleges throughout the United States. Cattle, lambs, and hogs were included and by 1930 about twenty-five States had taken part.

From 1924 onward, the Federal Division of Livestock, Meats, and Wool conducted grading demonstrations in many States in coöperation with the Federal-State Extension Service or, occasionally, with other State agencies. In 1924 such demonstrations were held in Arizona, California, Colorado, Nevada, and Utah, and in 1925 they were carried into Colorado, Nevada, New Mexico, South Dakota, Utah, Wyoming, and Virginia, in the last in coöperation with the State Division of Markets. In 1931, in coöperation with the Federal Extension Service and the Federal Board for Vocational Education, conferences of county agents and teachers of vocational agriculture were attended in sixteen different States. Livestock-grading demonstrations were held on farms in nine States in coöperation with the State extension services. This type of activity continues on a large scale.

In 1924, meat-grading demonstrations were held by the Division for the benefit of officers of the United States Army, Navy, and Marine Corps responsible for meat purchases. In 1924, also, demonstrations were developed at the request of the U. S. Shipping Board for the steamship lines and fleets under its control. In Philadelphia, such demonstrations were given for the officials of State institutions. The meat-grading service was gradually extended to various Federal, State, and municipal agencies which

are large purchasers of meats. These included the U. S. Shipping Board, the Veterans' Bureau, Federal hospitals, and Federal penal institutions.

Marketing beef and dairy products.—In 1925, a detailed study of the problem of producing and marketing beef cattle was begun in coöperation with the Virginia Agricultural Experiment Station. Slaughter tests were included and the food quality of the beef determined in coöperation with the Federal Bureau of Home Economics. Similar studies were begun in five corn-belt States. The nation-wide study of quality and palatability of meat which developed from this beginning has been mentioned above. In California, a study of the economic aspects of the beef-cattle industry, made by the California Station Division of Agricultural Economics (5—461) in 1928, acknowledged assistance from the Federal Bureau of Agricultural Economics, the Cattle Protection Service of the California State Department of Agriculture, and the Divisions of Animal Husbandry and Forestry of the University of California College of Agriculture.

The principal dairy products are fluid milk, cream and butter, and cheese, groups which are discussed separately below. The only coöperation noted in the marketing of dairy cattle themselves was by the Federal Dairy Division and the U. S. Shipping Board in the transportation of dairy cattle from the United States to France after the World War.

Surveys of dairy-marketing conditions and methods were made from about 1917 onward by the Federal Bureau of Markets in coöperation with State agencies, including the Extension Division in New Hampshire, the State Commissioner of Agriculture in Vermont, and the College of Agriculture in Mississippi.

By 1923, the Federal Division of Dairy and Poultry Products had obtained the coöperation of officials in various States in making statistics of dairy production promptly available, and a previous handbook of dairy statistics was revised. Thereafter, coöperation was developed with the States in obtaining semiannual statistics of dairy manufactures. In 1925 this was changed to a quarterly basis.

With the development of grades and standards for butter and cheese, coöperative Federal grading services were established.

Those in the East were coöperative chiefly with commercial agencies, but those in the Middle West except Chicago, and all at far western points, were coöperative with State agencies.

In 1931, a national dairy conference, composed of representatives of Federal and State official agencies and commercial dairy interests, was held in St. Louis to consider the problems of the industry and a program of action. The Federal Division of Dairy and Poultry Products, with the assistance of other Divisions, compiled a special mimeographed report, which later was published by the Federal Department (94—124).

In California, the State Department of Agriculture began coöperation in 1922 with the Federal Bureau of Agricultural Economics in a livestock market-reporting service at San Francisco and Los Angeles. In 1924 this was expanded to include dairy and poultry products, and thereafter the annual statistical report (8—50, 71, 83, and 93) contained the results of this increasing coöperation. The methods of calculating certain of these statistics were determined at a joint conference of representatives of the State Department and the College of Agriculture in 1926. A study of the economic aspects of the dairy industry in California, conducted by the Division of Agricultural Economics at the California Station (5—437), received some assistance from the Food Research Institute of Stanford University, the Bureau of Dairy Control of the California State Department of Agriculture, and the assistant farm advisor of Alameda County.

A comprehensive discussion of California dairy products, published by the same Station Division (5—514) in 1931, acknowledged assistance from the Division of Dairy and Poultry Products in the Federal Bureau of Agricultural Economics, the Bureau of Foreign and Domestic Commerce in the Federal Department of Commerce, the Federal-State Crop Reporting and Market News Services, the Bureaus of Animal Industry and Dairy Control in the California State Department of Agriculture, the Los Angeles County Livestock Department, and the Los Angeles, Oakland and San Francisco Health Departments.

Extensive studies of the consumption of dairy products were undertaken by the Federal Bureau of Agricultural Economics from about 1924 onward, in coöperation with the State Experiment

Stations in Maryland, New Jersey (55—506), and Pennsylvania (66—245).

The Oregon Experiment Station and the Federal Division of Dairy and Poultry Products made a coöperative survey of dairy-marketing conditions in Oregon in about 1926. The Wisconsin Station in 1925 published a study of intensive dairying in New Zealand and Wisconsin (133—377), with financial assistance from the U. S. Department of Agriculture and the Wisconsin Cheese Producers' Federation.

Market milk: The marketing of fluid milk has received more attention from investigating agencies than any other branch of dairy marketing. This is owing to the large volume and widespread distribution of the industry, to the perishable nature of the product, and to the presence of many circumstances affecting the public health.

As early as 1915 the Dairy Division of the Federal Bureau of Animal Industry began extensive investigations of the unit requirements for producing market milk. Many were coöperative with the newly created Federal Office of Markets, and some with State agencies, with municipal health departments and commercial organizations sometimes assisting. They were continued through several years and resulted in numerous coöperative publications by State experiment stations between 1918 and 1921. Of three coöperative Federal publications, one concerning Detroit, Michigan (86—639) was a joint contribution of the Bureaus of Animal Industry and Markets; a study for northwestern Indiana (86—858) was conducted coöperatively with Purdue University Extension Division; and an investigation for eastern Nebraska (86—972) acknowledged coöperation from the State Station.

Federal-State coöperation was abundant. From 1922 the Bureau of Agricultural Economics was the Federal agency. It gave financial assistance to the California Station in a study of the costs of producing market milk in 246 dairies during 1922 and 1923 (5—372), and also assisted the Illinois Station from 1924 to 1927 in a study on the distribution of fluid milk in four market areas (26—318). In New England, the Bureau's Division of Coöperative Marketing made an extensive study of the marketing of milk and cream (90—16) in 1927, in common with several State ex-

periment stations, extension divisions, departments of agriculture, and the Federal Bureau of Dairy Industry. In 1928, an extension program was based on a study of the membership problems of four large fluid-milk coöperative marketing associations, which it conducted jointly with Cornell and Ohio State Universities.

The Federal Division of Dairy and Poultry Products, also, has coöperated with several State agencies. Two early studies with Cornell University Station covered costs and methods of fluid milk production (57—445), published in 1925, and the demand side of New York milk marketing (57—459), the New York City Department of Health assisting in the latter case. The Division also coöperated with the Pennsylvania Station on the relation of the basic-surplus marketing plan to milk production (66—231), and with the Virginia Station on markets for milk (125—263), with publication of both investigations in 1928. Later, with the New Jersey Station, a coöperative study was made of the milk supply of the metropolitan market (55—515), and with the Wisconsin Station a similar study was made of the milkshed tributary to Milwaukee and Chicago (134—113), published in 1930 and 1932 respectively.

Two Federal interbureau coöperative investigations were noted. In 1922, the Bureaus of Markets and Animal Industry (Dairy Division) published such a study of producers' coöperative milk-distributing plants (86—1095). Recently, the Bureaus of Agricultural Engineering and Dairy Industry joined in a study of refrigeration in the handling, processing, and storing of milk and milk products (94—134).

Only intrastate agencies were involved in several recent coöperative studies. In Maine, the Experiment Station and the State Department of Agriculture coöperated in an economic study (34—367) of milk production and use. In Michigan, the Station Dairy and Bacteriology Departments coöperated in experiments to improve the milk supply of a city milk plant (38—112). A study of the marketing of milk in Michigan, made by the Agricultural Economics Section of the Experiment Station with the aid of the Dairy and Economic Departments of the State College and the Bureau of Dairying of the State Department of Agriculture was published (38—189) by the Station in 1929. In New Hampshire, the Station

Divisions of Dairy Husbandry and Marketing jointly issued a study of retailing milk (54—272). The Vermont Station study of the effect of extension education on the problem of the seasonal surplus milk (124—330) acknowledged coöperation from the Extension Division and data from the State Department of Agriculture. In New York, the supply side of the New York City milk market was investigated by Cornell Experiment Station (57—527), with coöperation from the State Department of Agriculture and Markets, the New York City Health Department, and commercial agencies.

In California, in 1930 and 1931, economic surveys were made of the Los Angeles milk market (5—513) and the East Bay (Oakland and neighborhood) milk market (5—534) by the Station Division of Agricultural Economics, with assistance acknowledged from the Bureau of Dairy Control of the State Department of Agriculture, the Los Angeles County Livestock and Health Departments, the city health departments of Berkeley, Hayward, Los Angeles, Oakland, Richmond, San Francisco, and San Leandro, and county farm advisors in the East Bay milkshed, as well as from commercial agencies.

Cream and butter: Studies of the marketing of cream and butter were begun at the same time as those concerned with fluid milk, and were made by the same agencies. In 1914 and 1915, the Federal Office of Markets and the Dairy Division of the Bureau of Animal Industry made a survey of butter markets in the South, published (112—66) in 1916, and a study of the prices and quality of creamery butter, published (86—682) in 1918. The Office of Markets coöperated also with the Wisconsin Station (133—270) in a study of the marketing of Wisconsin butter.

A coöperative study of the marketing practices of Minnesota and Wisconsin creameries, involving the Federal Bureau of Markets, the Agricultural Experiment Stations of the two States, and the Minnesota State Bureau of Dairying, was published by the Federal agency (86—690) in 1918. The Oregon Experiment Station coöperated with the Federal Bureau of Markets in a survey of typical Oregon farmers' creameries, published (63—168) in 1920.

Some years later, another series of coöperative studies was begun by the Division of Dairy and Poultry Products in the Federal

Bureau of Agricultural Economics. One of the early coöperative studies, covering the economic aspects of creamery organization, was published by the Minnesota Experiment Station (41—26) in 1924, with acknowledgment of help from the State Dairy and Food Department. In Oregon, coöperation with the Experiment Station on a survey of cream and marketing problems resulted in a publication (64—74) in 1926. In Indiana, a study of the effect of the time element in marketing cream on the quality of the resulting butter, made in coöperation with the Station Dairy Department, was published (28—383) in 1933.

In July of 1922, the College of Agriculture Division of Dairy Industry made a coöperative agreement with the Federal Bureau of Dairy Industry for a two-year study of the standardization and improvement of California butter, which was published as by the Experiment Station (5—443) in 1927. The coöperation was discontinued at the end of the two years by previous agreement, the State having obtained additional financial support and the Federal agency desiring to encourage similar enterprises elsewhere.

A few instances of intrastate coöperation occur. In Kansas, the Station Divisions of Agricultural Economics and Dairy Husbandry joined forces in a study of the organization and operation of coöperative creameries, published (31—259) in 1932. In Missouri, the corresponding divisions studied the development of new markets for Missouri butterfat, published by the Experiment Station (45—267) in 1929. In Idaho, the Departments of Agricultural Economics and Dairy Husbandry of the College of Agriculture and the Bureau of Dairying of the State Department of Agriculture coöperated in a study of the efficiency of cream stations in cream collections, published under joint authorship as by the Experiment Station (24—193) in 1932.

In 1924, there was begun in Minnesota a joint Federal-State inspection service covering butter shipments to distributing markets. At the same time, these agencies inspected increasing quantities of butter for the purchasing departments of Federal, State, and municipal governments. Butter also was included with other dairy products in the Federal-State Market News Service.

Cheese: Numerous coöperative investigations of the problems of the manufacture of cheese were discussed in the chapter on Animal

Industry. There has been relatively little coöperation on the problems of marketing cheese.

From about 1921 onward, the Federal Division of Dairy and Poultry Products assisted the various State marketing bureaus in formulating grades and standards for the different types of cheese. As the work developed, Federal-State coöperation was extended to cover grading service on this commodity at practically all mid-western and western markets. Cheese likewise was included in the Federal-State Market News Service in important cheese States.

In California, in 1925, the Station Division of Dairy Industry and the Federal Bureau of Dairy Industry jointly authored a study of the manufacture of a Roquefort type of cheese from the milk of goats (5—397).

In Wisconsin, as early as 1913, the Experiment Station coöperated with the State Board of Public Affairs in a study of cheese marketing (133—231). From 1925 to 1927, the Station and the Federal Division of Coöperative Marketing collaborated in a study of the operation of cheese factories making American cheese (134—100) and foreign types of cheese (134—103).

Sheep, wool, and mohair marketing.—Relatively little coöperative attention has been given to the marketing aspects of the sheep and lamb industry, but more to wool grading and marketing.

Sheep and lambs: As early as 1920, the Federal Bureaus of Markets and Animal Industry coöperated in a study of the castrating and docking of lambs in relation to market quality (87—1134). In 1924, the Federal Division of Livestock, Meats, and Wool, in coöperation with the Agricultural Extension Services of Tennessee, Virginia, and West Virginia, and with commercial interests, studied the improvement and standardization of the quality of eastern lambs. In 1930, this Division, in coöperation with the Bureaus of Animal Industry and Home Economics of the Federal Department, conducted a lamb-mutton slaughter test, demonstrating that the grading of live lambs and sheep correlated closely with the later grading of their carcasses (98—1930:36).

In California, a study of the economic aspects of the sheep industry was jointly authored (5—473) in 1929 by the Station Division of Agricultural Economics and the Federal-State Livestock Market News Service. Information on the movement of sheep to

and from the ranges was furnished by the Division of Animal Industry of the State Department of Agriculture.

Wool: Extensive coöperative activities in the grading and marketing of wool occurred during the period of the World War. Type samples of commercial grades of wool were prepared by the Federal Bureau of Markets in 1918 at the request of the Quartermaster Office of the War Department. Later activities in grading and marketing were maintained in coöperation with the Departments of Navy and War, the Council of National Defense, the U. S. Shipping Board, the Federal Tariff Commission, the War Industries Board, and the War Trade Board.

In 1922, Federal investigations of the commercial marketing of wool were made in Colorado and wool-grading demonstrations conducted before classes at the State Agricultural College. Sets of the tentatively established wool grades were widely distributed to interested agencies, including many of the State colleges of agriculture. During 1924, three master sets of correlation samples of wool standards were prepared, one for the U. S. Department of Agriculture, one for the U. S. Bureau of Standards, and one for use in England. During the year, an official was sent to England to confer with British authorities on the correlation of American wool standards with the British standards, this correlation being completed in the following year, with the aid of the Federal Bureau of Standards and United States and British manufacturers.

In 1927, official Federal standards for grades of wool were promulgated and more than 100 complete and nearly 150 partial sets prepared for distribution. Many were loaned to State colleges and universities and the county agricultural agents for use in teaching and demonstration. The standards were approved by the Pan-American Standardization Conference held in the city of Washington under the auspices of the Inter-American High Commission. Later, the Federal Congress made these wool standards the determining authority on the grade of imported wools in the Treasury Department for customs purposes. From the establishment of the tentative wool grades onward, demonstrations and grading schools were held in coöperation with the State agricultural colleges, beginning with Indiana, Ohio, and Utah in 1925, and progressing to Nebraska and the Dakotas in 1933.

In 1927, the Federal Division of Livestock, Meats, and Wool assisted the North Dakota Agricultural College by classifying 285 samples of wool representing a study of inheritance. In that year and the following, the Division coöperated with the Utah Agricultural College in a study of the density and quality of fleece of different range flocks. Coöperative relations have been maintained with the Bureau of the Census of the U. S. Department of Commerce in the preparation and publication of statistics on dealers' and manufacturers' stocks of wool.

Mohair: The angora goat and mohair industry was made the subject of coöperative study by the Division of Livestock, Meats, and Wool, the Bureaus of Animal Industry and Forest Service of the U. S. Department of Agriculture, and the Bureaus of Standards and Foreign and Domestic Commerce in the Federal Department of Commerce and the results published (92—50) in 1929.

Swine marketing.—Some information on the grading and marketing of swine is contained in the general discussion of the marketing of livestock and meat. The volume of coöperative activity is relatively small.

The question of soft pork produced in the southern States by the use of oily feeds such as cottonseed and peanuts was discussed from the production standpoint in the chapter on Animal Industries and also in the preceding section of this chapter under Sheep, Swine, and Poultry Management. The marketing aspects of this problem were studied by the Federal Bureau of Markets as a part of the general coöperation involving the Federal Bureau of Animal Industry and the experiment stations and extension divisions of the southern colleges of agriculture. Data on the shrinkage of soft pork under commercial conditions were published by the Federal marketing agency (86—1086) in 1922.

In California, an economic study published by the Experiment Station (5—523) in 1932 contained numerous data on swine marketing. Prepared by the Station Division of Agricultural Economics, it acknowledged valuable assistance from the Federal Bureaus of Agricultural Economics and Foreign and Domestic Commerce, the Federal-State Coöperative Crop Reporting Service, the Federal-State Livestock Market News Service, the Division of Animal Industry of the State Department of Agriculture, the Division of

Animal Husbandry at the California Station, and the farm advisors of several California counties.

In 1926 and 1927, the Federal Division of Livestock, Meats, and Wool coöperated with the agricultural experiment stations of several corn-belt States on different phases of marketing swine. The Illinois study covered the adjustment of hog production to market demand (26—293) ; in Indiana, the feeding and marketing of early spring pigs (28—310) ; and in Iowa, the direct shipping and selling of hogs. A later study of conditions affecting the dressing percentage of hogs was made by the Ohio Station (61—505), with financial assistance from the Division of Livestock Marketing of the Federal Farm Board for out-of-State travel to eastern markets, and help from the Federal-State Extension Service.

Poultry and Poultry-Products Marketing

Federal attention to the marketing of poultry and eggs developed early in the Bureau of Chemistry and became coöperative with the Bureau of Markets in 1919.

A comprehensive statistical and economic survey of the poultry industry, made by the Federal Bureaus of Agricultural Economics and Animal Industry, was published (96—1924:377) in 1924. A study of European marketing methods and market requirements, entailing some official coöperation, was published (86—1385) in 1926. The first-named Bureau published a bibliography on the economic aspects of the poultry industry (99—24) in 1928.

The California Experiment Station published (5—413) a statistical study of the poultry industry in 1926, in which contributions of time and effort from the Federal Bureaus of Agricultural Economics, Census, and Foreign and Domestic Commerce, the State Department of Agriculture, and numerous commercial agencies were acknowledged.

The Federal Division of Dairy and Poultry Products coöperated with the University of Illinois in a study of poultry-consumer habits and practices during 1929 and 1930, and in 1925 with the North Carolina State Division of Markets and Agricultural Extension Service on better methods of marketing poultry and eggs.

In North Dakota, the Station Department of Marketing, with assistance from extension poultrymen, and from the Federal Divi-

sion of Dairy and Poultry Products, conducted a study of poultry and egg marketing (60—215) in 1928. The Ohio Station published in 1928 a business study (61—427) of the Ohio Poultry Producers' Coöperative Association, with assistance acknowledged from the Federal Division of Coöperative Marketing.

Poultry Marketing.—Coöperative activities in the marketing of poultry began about 1924, when the Federal Divisions of Dairy and Poultry Products and Animal Husbandry collaborated in studies of marketing baby chicks and the compiling of a handbook of poultry statistics. Beginning in about 1926, the Division of Dairy and Poultry Products, at the request of the attorney general of New York, coöperated with the New York Food Marketing Research Council in an extensive survey of wholesale marketing of live poultry (89—107).

A turkey-grading service was started in coöperation with official agencies in the State of Washington as early as 1927, and by 1930 coöperative grading of turkeys was under way in California, Colorado, Idaho, Nevada, Oregon, Utah, Washington, and Wyoming. Two popular discussions of turkey grading were published (96—1930:525 and 1931:531).

Tentative United States standards and grades for dressed poultry were issued in 1927. A grading service was started at Washington, D. C., in order to test these grades, and proved satisfactory to the purchasing departments of several State institutions, as well as for the Marine Corps, the Veterans' Bureau, and the hospitals maintained under jurisdiction of the Department of the Interior. The Federal inspection was discussed (96—1928:498) in 1929.

Egg marketing.—In 1922, assistance was given by the Federal Bureau of Markets to State marketing bureaus in the formulation of grades for eggs. Tentative United States classes, standards, and grades were issued in 1923 and revised in 1924. In 1923 a standardization campaign was conducted in coöperation with the Missouri Bureau of Marketing. In January, 1924, the tentative standards for eggs were the subject of conference between the Division of Dairy and Poultry Products and State and commercial agencies, resulting in a typed report of 275 pages. Thereafter, standardization programs were promoted in Indiana, Missouri, Vermont, and West Virginia in 1924, in coöperation with the Federal-State

Extension Services. Numerous other States made requests for such assistance in the following years. By 1925, assistance was given to the extension divisions in twenty-two State colleges of agriculture in demonstrations of egg candling, grading, packing, and loading.

In California, coöperation was arranged with the State Department of Agriculture and a Federal-State inspection service for eggs was established at San Francisco and Petaluma in 1926. Gradually, the service was extended to other shipping points in 1927 and to Los Angeles in 1928.

Egg inspection was established in Missouri in coöperation with the State Marketing Bureau in 1926, in Virginia in coöperation with the State Bureau of Markets in 1928, and in West Virginia in coöperation with the new State poultry-marketing plant at Parkersburg in 1928. By 1928, at least eight States, California, Georgia, Louisiana, Maine, Massachusetts, New York, Rhode Island, and Wyoming, had established egg grades based wholly or in part on the Federal standards and grades. Market reports on eggs were included in the Federal-State Market News Service as the Service was developed throughout the country, in coöperation with State agencies. Grading service on eggs, as well as on butter and cheese, was extended to new offices established in Portland and Seattle, the latter in coöperation with the Washington State Department of Agriculture, in 1930. The practical value of egg standardization was set forth (96—1928:267) in 1929.

The Federal Division of Dairy and Poultry Products assisted the Delaware Station Division of Economics in a study of the marketing of eggs (13—150) in 1927, and the Minnesota State Department of Agriculture in 1925 on a study of the deterioration of eggs transported by boat from Duluth to New York City. In Oklahoma, a three-month demonstration of marketing eggs on a quality or grade basis was held in coöperation with the Extension Division of the Agricultural College in 1926. Grading schools and demonstrations have been continued in other States in the succeeding years. In Texas, the Federal Division coöperated with the Texas Extension Division in a study of methods and practices in marketing eggs.

In Missouri, the Station Divisions of Agricultural Economics and Poultry Husbandry made a joint study of consumer preferences for

egg-yolk color and shell color in New York City, which was published by the Missouri Station (45—329) in 1933.

Honey Marketing

Official activities in the marketing of honey are relatively recent. In 1923, the Federal Division of Livestock, Meats, and Wool collaborated with the Division of Bee Culture of the Federal Bureau of Entomology in determining color standards for honey (91—364). The coöperation was continued and by 1926 the two agencies had formulated Federal recommended grades and standards for comb and extracted honey, published (90—24; 91—410) in 1927 as joint contributions. From 1927 to 1929, the Division of Livestock, Meats, and Wool coöperated with the Cornell University (New York) College of Agriculture in a study of conditions affecting the coöperative marketing of honey by the producers in that State.

In California, the Federal Bureau of Entomology has established the Pacific Coast Bee-Culture Field Laboratory in coöperation with the California Agricultural Experiment Station. In 1931—32, the Station Division of Agricultural Economics coöperated with this laboratory in a comprehensive study, jointly authored, of honey marketing in California (5—554) and the bee industry (5—555).

The publications in the Literature Cited at the end of this chapter which have been cited in this subsection on Commodity Marketing Studies in the section on Marketing Agricultural Products are Nos. 1, 3, 5, 7, 8, 11, 12, 13, 20, 22, 23, 24, 26, 28, 31, 33, 34, 37, 38, 40, 41, 42, 44, 45, 47, 54, 55, 57, 58, 60, 61, 62, 63, 64, 66, 69, 73, 77, 86, 87, 89, 90, 91, 92, 93, 94, 95, 96, 98, 99, 105, 106, 110, 111, 112, 124, 125, 128, 133, and 134.

5. LAND ECONOMICS

THE SUBJECT OF LAND ECONOMICS is exceedingly complicated. From the standpoint of agriculture, it is concerned with land classification, reclamation, and use, with reference to the production of crops and livestock. From the standpoint of economics, it is concerned with basic statistics on production, population, and consumption trends, land values, reclamation costs, settlement prob-

lems, marketing problems, taxation, and agricultural credit. Beyond these lie the less tangible problems of rural sociology.

Land classification is fundamental to rational and profitable land use, but land classification must go much farther than a determination of the relative values of different areas for crop and livestock farming. It must be concerned with land utilization in its broadest sense. This will include not only agriculture but forestry; water conservation and use, including flood control, irrigation, and power production; wild-life conservation, production, and use; recreational opportunities, including hunting and fishing areas and scenic values; and, finally, properly planned urban expansion. It entails nation-wide attention to the increasing problem of soil erosion and consequent impairment or destruction of land values.

The problem is complicated further by the fact that no large area can be consecrated wholly to any one of these purposes. Most areas, even small ones, must and should contribute to several of them. For instance, areas devoted chiefly to forestry contribute to water conservation, flood control, erosion control, wild-life conservation, recreation, scenic values, and livestock production.

Land reclamation likewise includes economic problems in both engineering and agriculture. Among them are land drainage, irrigation structures and practices, alkali removal, erosion control, flood and debris control, stump and stone removal, fire prevention, and revegetation of denuded areas. Attention is given here to statistical bases, land values, farm ownership and tenancy, settlement and colonization, land reclamation, and land classification and utilization.

STATISTICAL BASES

Statistical compilations of crop and livestock production, their geographical distribution and their mathematical trends, are basic to an understanding of land use for agriculture. The annual compilation of these data through the coöperative Federal-State Crop Reporting Service has been discussed in section 2 of this chapter. The coöperation of these agencies with the Federal Bureau of the Census in its decennial and five-year censuses of agriculture has been discussed also. Certain special presentations should be mentioned here.

Graphic Summaries of Agriculture

Compilations entitled *Graphic Summary of American Agriculture* were published first in 1916 and again in 1922 and 1931. The first represented a collaboration of the Federal Bureau of Crop Estimates and Office of Farm Management (96—1915:329) and contained data based on material assembled by the Bureau of Crop Estimates through its Federal-State coöperation, and by the U. S. Bureau of the Census, with additional information or interpretations from the Bureaus of Plant Industry and Animal Industry. The second summary (96—1921:407), prepared by the Office of Farm Management, was based on data derived from the agencies mentioned above. The third, based largely on material from the census of 1930, was published by the Division of Land Economics (94—105) in 1931. Similar graphic summaries of world agriculture, also, with similar coöperation, were published by the Federal Department of Agriculture (19; 96—1916:531) in 1916 and 1917.

After the beginning of the agricultural depression in 1921, the Federal Department of Agriculture held national agricultural conferences with representatives of the State colleges of agriculture, farmer organizations, the farm press, organized labor, and numerous commercial agricultural industries. Thereafter, it sponsored a historical, statistical, and economic survey of each of the major agricultural industries of America. These were prepared in coöperation by the Bureaus of Agricultural Economics, Animal Industry, and Plant Industry, and the Forest Service, with assistance from several other Bureaus such as Chemistry, Home Economics, Entomology, Soils, and Weather. Much of the material used was derived from the accumulations of the Federal-State Crop and Livestock Reporting Service, and the Federal Bureau of the Census. The statistical and graphic results were published in the Department *Yearbook* for the years 1922 to 1925, inclusive (96).

Special Census Coöperation

The Federal Bureau of the Census obtained data on pasture land in farms of the United States in the census of 1910, but lack of funds prevented their tabulation. Permission was given later to

the Office of Farm Management to tabulate the data, and these were published (86—626) in 1918.

The Section of Land Economics in the Federal Office of Farm Management and Agricultural Economics coöperated with the Bureau of the Census in formulating six questions on land use to be included in the Federal census of 1920. The two agencies then co-operated in tabulating them by townships for joint publication. Similar collaboration in the special agricultural census of 1925 obtained actual statistics of land utilization for the first time, and the schedules were used again for 1930.

The Connecticut (Storrs) Agricultural Experiment Station published (12—127) in 1925 a description of Connecticut agriculture, toward which the Federal Division of Land Economics contributed the clerical staff for tabulating the answers to forty questions in the individual census returns of 1920.

FARM LAND VALUES

The high level of values for farm lands, following wartime high prices for agricultural products, brought about several coöperative studies. Farm-land values bear also a direct relation to agricultural finance.

The Federal Office of Farm Management and Farm Economics, in coöperation with the Iowa State College of Agriculture, made a study of the phenomenal rise in land values in that State in 1919, the culmination of a five-year increase in prices (86—874). A similar coöperative study of the relation of land prices to land speculation in the Bluegrass region of Kentucky was published by the State Experiment Station (32—240) in 1922.

The advent of the agricultural depression in 1921 caused an increased interest in farm values in relation to other factors, and started a series of coöperative or independent studies, which continue. Such early investigations were conducted in Colorado (11—318), Iowa, Indiana, and Illinois (26—399), all in coöperation with Federal agencies, the Iowa study including the Federal Bureau of Public Roads.

Long-time records of land prices were compiled by the Federal Division of Land Economics, beginning in 1925, from county records of sales and other sources, with the collaboration of county

officials. These studies were begun in Alabama, Illinois, Indiana, Iowa, Kentucky, Missouri, Georgia, Nebraska, North Carolina, South Carolina, Tennessee, Texas, and Wisconsin (98—1925:52). In 1926, the Federal Division of Land Economics compiled data on land-value changes from 1920 to 1926 (96—1926:470-76), and also made the first of a continuing series of annual surveys (91—377) of the farm real estate situation occasioned by mortgage foreclosures and by bank failures in the agricultural areas (90—15, 60, 101, 150, 209, 261, and 309).

The Federal Bureau of Agricultural Economics published, in 1929, a bibliography on the valuation of real estate with special reference to farm real estate (99—29).

Short Courses in Land Valuation

The problems of the management and disposal of foreclosed farm properties have developed a demand for additional information on land appraisal. To supply this need the Federal Division of Land Economics, the Federal Land Banks, and other agencies have co-operated with the State colleges of agriculture in organizing and conducting short courses in land valuation.

In California, such a conference was held in January, 1926, at the University of California. The proceedings were never published but notes taken were filed with the Federal Land Bank of Berkeley (99—29:58). At the Iowa State College, such short courses were held annually from 1925 at least until 1928 (99—29:60). The University of Missouri held land-valuation short courses in 1927 and again in 1928, and promptly published summarized reports of the lectures given, which included coöperative participation by the Federal Division of Land Economics and the Federal Land Bank (45—255 and 269). In Minnesota, similar coöperation was given in short courses held at the University of Minnesota, beginning in 1928. From 1930 onward, similar coöperation was given by the Federal agencies mentioned to State colleges of agriculture in several more States.

Following the disastrous floods in the Mississippi Valley in 1927 and the development of a flood-control program by the Corps of Engineers of the United States Army, several Bureaus of the Federal Department of Agriculture took part in appraising agricul-

tural lands affected by this program, and a preliminary report covering 700,000 acres was submitted on February 1, 1931.

• FARM OWNERSHIP AND TENANCY

Studies of farm ownership and farm tenancy, some coöperative and others independent, were begun by the Federal Office of Farm Management about twenty years ago (96—1916:321), although one study was made on farm leases, in coöperation with the Iowa Station (29—159) in 1913, while the Office was yet in the Bureau of Plant Industry. From 1916 onward, the Office coöperated with the Federal States Relations Service in studying tenancy on wheat farms in Kansas, Nebraska, South Dakota, North Dakota, and Minnesota, and stock-share renting in Iowa (in coöperation with the Experiment Station), Illinois, Indiana, Michigan, Ohio, and Mississippi.

In 1924, the Federal Divisions of Land Economics and Farm Management and Costs collaborated in preparing a 93-page statistical summary of farm ownership and tenancy, which embodied census data and the results of both coöperative and independent investigations by many agencies (96—1923:507). In 1926, the Federal Division of Land Economics and the Bureau of the Census published an analysis of data from the censuses of 1900 and 1920 on ownership of tenant farms in 184 well distributed counties (86—1432), of which 85 in the North Central States also were published in greater detail (86—1433).

From 1920 onward, the Federal Office of Farm Management and Farm Economics, and from 1922 the Federal Division of Land Economics, have coöperated with State experiment stations, and often with extension divisions also, in studies of farm ownership and tenancy. In the southern States these investigations covered renting farms (125—249), involving coöperation of the Virginia Water Power and Development Commission, and stock-share renting (125—271) in Virginia; farm tenancy in central Kentucky (32—303); rental problems of the farm tenant in Missouri (45—315), in which the Station Division of Agricultural Engineering also aided; and ownership and tenancy in the black prairie district of Texas (86—1068) in which both the Agricultural College and State University assisted.

In the North Central States, Federal-State coöperation included studies on corporate-owned land in Iowa (29—307), and the various phases of farm tenancy in Nebraska (50—185, 191, 202, 205, and 210). In Wisconsin, how farmers become owners (133—402) was studied by the State Experiment Station with the coöperation of county auditors.

In about 1920, the Section of Rural Life Studies in the Federal Office of Farm Management and Farm Economics began coöperative investigations of the social aspects of farm tenancy in about sixteen States. These were continued after 1922 by the Federal Division of Farm Population and Rural Life. Among others, these studies included the social aspects of farm sales in Indiana, of rural life and farm tenancy in Cedar County, Iowa (29—217), and of some community phases of farm tenancy in Nebraska (50—196).

LAND SETTLEMENT AND COLONIZATION

Land colonization scarcely can be separated from land reclamation, because colonization enterprises usually involve drainage, irrigation, or land-clearing projects. The release of some 4,000,000 young men from the Army of the United States following the conclusion of the World War in 1918 raised anew the old question of land settlement by soldiers and sailors, and this has continued a live topic in spite of the agricultural depression of 1921.

In Wisconsin, in 1918, a discussion of farm making for new settlers in the cutover lands of the northern part of the State was prepared jointly by the Experiment Station (133—290) and the Director of Immigration of the Wisconsin State Department of Agriculture.

The Federal Division of Land Economics in 1920 began studies of land settlement and colonization in the cutover areas of the Great Lakes States in coöperation with the Minnesota and Wisconsin Experiment Stations and the University of Michigan. The U. S. Forest Service also joined in the study, which was published (86—1295) in 1925. A follow-up survey of the same area, begun in 1927 by the same agencies and the Wisconsin Department of Agriculture, also, was published (90—160) in 1931.

A general field study of official State activities in the promotion, control, and supervision of land settlement was begun by the Fed-

eral Division in 1923 with some assistance from the various States concerned, but the data never were published. Recently, the acute unemployment situation due to the general depression caused the Division to summarize Federal and State land-settlement problems and policies (89—357) with a comprehensive discussion in 1933, some of the cooperating official agencies in each State being indicated.

LAND RECLAMATION AND PROTECTION

Land reclamation comprises, among other things, the drainage of overflowed, swamp, and tide-marsh lands; the irrigation of arid and semiarid lands; the removal of injurious alkalies; the clearing of land of stumps, brush, and stones; the revegetation of denuded areas, including overgrazed range, shifting sands, and forest areas injured by fire, smelter fumes, and injudicious grazing; and finally, the control of destructive erosion. Many of these are engineering problems or at least have large engineering features. Drainage has been discussed already, in the chapter on Agricultural Engineering, and irrigation has a large place in the chapter on Water Resources. Alkali control is closely connected with drainage. Land clearing was discussed under Agricultural Engineering and briefly mentioned under Farm Management in the present chapter. Erosion control has been presented both in the chapter on Soils and in that on Agricultural Engineering. The reclamation of denuded areas has had minor discussion of smelter injury in the chapter on Agricultural Chemistry and of range improvement in the chapter on Plant Industry, while the problems of reforestation are discussed in the chapter on Forest Resources in the volume on Natural Resources.

We are concerned here with only those studies made primarily from the standpoint of land economics, usually where serious financial difficulties have arisen.

In 1923, the Federal Division of Farm Management and Costs, in cooperation with the Division of Agricultural Engineering in the Bureau of Public Roads, began a study of the costs of establishing going farms on reclaimed land (98—1923:184). In the following year they completed a cooperative study of economic results obtained by settlers on five reclamation projects in Texas and New Mexico. At the same time, the Division of Land Economics began

a comprehensive survey of the methods employed in various States in promoting land reclamation and land settlement, the results being recommended for publication (86—1257) by the Committee of Special Advisors on Reclamation appointed by the Secretary of the Interior. Similar coöperative studies of economic limits of water costs in irrigation were continued for several years and mimeographed reports issued from time to time.

In 1926, the Division of Land Economics, in coöperation with the Section of Drainage Investigations began a study of numerous land-drainage enterprises and the degrees of their success in meeting financial obligations.

In California, in 1927, the State Station, in coöperation with the Federal Land Bank of Berkeley, studied the problem of securing a closer relation between agricultural development and irrigation construction (5—435), including a discussion of land-settlement policies (pp. 97—99).

In one study of injury or destruction to vegetative cover by smelter fumes, agricultural economists took part. A special study of economic damage caused by smelter fumes in the Columbia River Valley in northeastern Washington was made by the Bureaus of Agricultural Economics, Chemistry and Soils, and Plant Industry in 1931, at the request of the Department of State and on funds provided by it, because the smelter was located in British Columbia and the problem was international.

LAND CLASSIFICATION AND UTILIZATION

Adequate land classification is absolutely fundamental to a land-use program. Full discussion of land classification is given in the chapter on Land Resources in the companion volume on Natural Resources. Soil classification which, in its turn, is fundamental to land classification and use, has been discussed as to objective, progress, and coöperative activities, in a preceding chapter on Soils and Soil Management in Volume I.

Classification for Homestead Purposes

The homestead laws of 1862, 1909, and 1916 did not take account of the relative value of the land for agriculture and for other uses, but the last two laws allowed a larger acreage under specified con-

ditions. While the Stock Raising Homestead Act of December 29, 1916, is administered by the General Land Office, the responsibility for proper classification of the land was vested in the Land Classification Board of the U. S. Geological Survey, which obtained the coöperation of the Federal Bureaus of Soils and Plant Industry. The first-named Bureau gave expert advice on the water holding and agricultural capabilities of the soil, while the Bureau of Plant Industry determined from surveys of the native vegetation the probable carrying capacity for livestock and productivity for crops.

Classification for Use

With the agricultural depression, beginning in 1921 and entailing the failure of some 10,000 banks in agricultural areas during the middle twenties, the terrific deflation in farm values, and the consequent increasing foreclosure of farm mortgages and tax delinquency of agricultural land, the whole problem of the proper classification of land as between agriculture and other uses came sharply into the foreground. The recent increasing volume of land-classification and land-utilization studies has been developed quite largely from this viewpoint.

A Departmental Committee on Land Utilization was created in the Federal Department of Agriculture in 1921. This committee served to coördinate the field work of the Bureaus of Animal Industry, Plant Industry, and Public Roads (Agricultural Engineering Division), the Office of Farm Management and Farm Economics (later in the Bureau of Agricultural Economics), and the Forest Service in the various States. The chief of the Division of Land Economics in the Office of Farm Management was made chairman of the committee.

A general survey of the utilization of land for crops, pasture, and forests, was published on a comprehensive scale (96—1923: 415) in 1924, under joint authorship of the Bureau of Agricultural Economics and the Forest Service, with the collaboration of the other Bureaus mentioned and also of the Bureau of Biological Survey and the Agricultural Extension Service.

Beginning in about 1928, more intensive studies of land utilization were begun in several States. These covered questions of marginal and submarginal agricultural lands, the relation between

agriculture and forestry, and the relation of both to soil erosion and to erosion and flood control. At the same time, the Bureau of Agricultural Economics collaborated extensively with workers in the Federal, State, and county Agricultural Extension Services, and with other teachers and economists in explaining the new and complicated land-utilization problems to extension and other educational agencies.

Northeastern States

In New Hampshire, two studies relating primarily to State market demands for farm products (54—217 and 222) involved Federal-State coöperation, and a third (54—264), covering a survey of land holdings in two towns, was coöperative between the Agricultural Experiment Station and the New Hampshire Tax Commission. In Vermont a Federal-State study of land utilization as a basis for rural economic organization in thirteen hill towns (124—357) involved also the Vermont State Department of Forestry.

In Michigan, a study of agricultural land classification and land types was published (38—231) in 1933, with acknowledgment of assistance from the Federal Soil Survey, the Land Economics Survey of the State Department of Conservation, and the State Commission of Inquiry, and from county, township, and school district governments.

In New York, the Cornell University Department of Agricultural Economics began studies in 1924 and has continued with minor but increasing coöperation. They include the utilization of marginal lands (57—476) with assistance from the Department of Forestry; abandoned farm areas (57—490); land utilization in Tompkins County (57—590) and land utilization in Montgomery County (57—614), all with assistance from numerous county, town, and school district officials. The last two acknowledge coöperation of the Federal Division of Land Economics and the State Public Service Commission, respectively.

In Pennsylvania, a study of land utilization and farm management in Wyoming County, published (66—257) in 1931, was coöperative with the Federal Bureau of Agricultural Economics, with aid from the Federal Bureau of Chemistry and Soils and other Pennsylvania Station Departments. A similar intensive study was made in Tioga County. In Ohio, land-utilization studies were made

in Vinton County (61—485), and Lawrence County (61—514), with coöperation of county and township officials and a county agricultural agent.

In Wisconsin, tax delinquency in cutover areas became very serious. The Wisconsin Station Departments of Agricultural Economics and Agricultural Engineering, in coöperation with the Federal Bureau of Agricultural Economics and the Forest Service, studied the use and taxation of land in Lincoln County (133—406) in 1929, and thereafter coöperated in formulating a working plan for classifying land resources and determining land-utilization programs in northern Wisconsin, for the use of extension workers and county officials.

Southern States

By 1925, a detailed study of the use of cutover lands in the cotton belt was begun by the Federal Division of Land Economics in the pinewoods section of the South Atlantic and Gulf States, with some State coöperation. In 1928, the Division began economic and social studies (94—205), including better land utilization for forests and farms in the mountainous areas of the southern Appalachians, involving coöperation with the U. S. Department of the Interior, as well as the Federal Forest Service and Bureau of Home Economics, other Divisions of the Bureau of Agricultural Economics, including the Division of Agricultural Finance, and the experiment stations of several States.

In Kentucky, the first Federal-State study was begun in 1928 in Laurel County (89—289), and was authored jointly by the Federal Division of Land Economics and the Kentucky Station Department of Farm Economics, other Divisions of the Federal Bureau of Agricultural Economics also taking part. A similar broad study was made in Knott County by these agencies with the addition of the Federal Bureau of Home Economics and Forest Service, and that portion of it dealing with forestry in the economic life of the county was published (32—326) in 1932.

In West Virginia, a study of land utilization in Nicholas and Webster Counties was begun in 1930 by the Federal Division and Forest Service, and the West Virginia College of Agriculture (89—303) with a full cover statement of coöperation, the Experiment Station publishing a summary (131—65) in 1933.

Great Plains Area

The proper agricultural utilization of the Great Plains became an agricultural problem early in the present century, as cattle ranching slowly gave way before the advance of homesteading. After the close of the World War and the beginning of the agricultural depression, the economic aspects of the problem became paramount. The Federal Bureaus of Agricultural Economics, Plant Industry, Soils, and Weather, together with the Land Classification Board of the U. S. Geological Survey, began a comprehensive survey of land utilization in coöperation with the Agricultural Colleges of Colorado, Kansas, Montana, North Dakota, and South Dakota, and preliminary mimeographed reports were issued. Maps showing land classification were prepared coöperatively by the Geological Survey and maps of the soils and natural vegetation and carrying capacity were prepared for publication in the *Atlas of American Agriculture* (100), an enterprise which represented coöperation by the five Bureaus mentioned above. The survey was gradually extended to the southern Great Plains.

Western States

In 1930, the President of the United States called the attention of the governors of the western States to the need for adequate legislation regulating the use of the remaining unreserved public domain. Later, with the approval of the Federal Congress, the President appointed a Committee on the Conservation and Administration of the Public Domain.

In California, a general study of the economic problems of California agriculture, containing a discussion of land utilization, was made by the Experiment Station in accordance with a request from the State legislature. The resulting study (5—504) covered a series of thirty hearings held in all parts of the State and made use of information obtained from the Federal Department of Agriculture and other Federal agencies. A comprehensive survey of the utilization of land in El Dorado County, California, one of the first of the new land-use planning studies, was coöperative between the California Forest and Range Experiment Station of the U. S. Forest Service, and the Division of Agricultural Economics at the

California Station, and was jointly authored (5—572) in 1934, with assistance in technical problems from the Station Divisions of Forestry and Soil Technology. This study is one of the first looking toward the best possible utilization of such marginal lands, toward the stabilization of decaying communities, and toward the many other conditions which are joint problems of land utilization and rural sociology.

In Colorado, a cooperative Federal-State study of land utilization in those mountainous areas in western Colorado affected by the Moffat Railway tunnel was begun in 1928. In Nevada, by the Federal Division, an extensive study was made of the problem of a better defined legal authority for the grazing use of public domain (89—301), with assistance acknowledged from other Federal agencies, such as the Forest Service, Geological Survey, etc., and from various State officers, the Agricultural Experiment Station and Extension Service, and county officials.

In Washington, the Experiment Station and the Federal Division of Farm Management and Costs have been cooperating recently in a study of present land uses in that State, of which the first part (128—288) was published in 1933.

RECENT LAND-USE PLANNING

With the advent of the general depression, land-use problems, already accentuated by the long period of agricultural depression, became increasingly acute. Public attention was focused upon them from many angles. Demands for the formulation of a national land policy increased in volume and emphasis (96—1932:457). Several Federal agencies, created to deal with different phases of the depression emergency, were concerned with different aspects of land-use planning. The membership and activities of the various committees and other organizations discussed below represent an enormous volume of cooperation between Federal, State, and local official agencies, and an equally significant coordination of their various plans and activities. Comprehensive plans included the public domain, prospective additions to it, reclamation enterprises and agencies, corporate holdings, and private farms, as well as relations between industrial workers and the land. This last matter covers part-time farming, from the suburban garden to the stabil-

ized community with its industrio-agricultural farmlets (subsistence homesteads). A bibliography on part-time farming (99—43) was published in 1933 by the Federal Bureau of Agricultural Economics.

Committee on Public Domain

A Committee on the Conservation and Administration of the Public Domain, composed of twenty members, including the Secretaries of the Departments of Agriculture and the Interior, was appointed by the President in accordance with an act of Congress approved on April 10, 1930. It was charged by the President with the consideration of the following problems: (1) the future disposition of the remaining vacant, unreserved, unappropriated public lands and the adoption of a definite program of conservation of grazing resources; (2) conservation of water resources, including reclamation and flood control; (3) conservation of subsurface mineral resources; (4) conservation of timber resources with special consideration of national forest areas; and (5) changes in administration which might produce greater efficiency in the conservation and use of the natural resources of the Nation. The committee went out of existence when its report (74) was presented to the President in January, 1931.

Taylor Grazing Act

Following the report of the Committee on the Conservation and Administration of the Public Domain, renewed efforts were made to obtain the passage of Federal legislation controlling overgrazing on the public range, which already had resulted in serious injury through wind and water erosion of partly or wholly denuded areas. This effort (72) culminated in the passage of the Taylor Grazing Act in the spring of 1934, following extensive hearings before the Committee on Public Lands of the House of Representatives in both 1933 and 1934 and before the similar Committee of the Senate in April and May, 1934. After the passage of the act, representatives of the General Land Office of the Department of the Interior, and of Bureaus of the Federal Department of Agriculture concerned with land, coöperated in conferences with stockmen in several of the western public-lands States.

In California and Oregon, the most important features of this

legislation were those tending to conserve the range as a public resource. In Nevada and Arizona, with their enormous areas of public domain, more than 50,000,000 acres lying in Nevada alone, the chief problem was the preservation of State interest in the use of this range land. The prompt approval of the legislation by the Nevada State Range Commission was a significant step in the administration of the Act.

National Conference on Land Utilization

The growing interest in the land problem resulted in the holding of a national conference on land utilization, called jointly by the Federal Secretary of Agriculture and the executive committee of the Association of Land-Grant Colleges and Universities. The conference was held in Chicago in November, 1931, and the proceedings published by the Federal Department of Agriculture (48) in May, 1932. This conference was the beginning of the present nation-wide setup of coöperating official agencies for national land-use planning. The conference itself did not hold another meeting but it recommended the creation of two committees.

National Land-Use Planning Committee.—The first committee was the National Land-Use Planning Committee, composed of fifteen representatives from official agencies. There was one each from the Bureaus of Agricultural Economics, Agricultural Engineering, Chemistry and Soils, Extension Service, and Forest Service in the U. S. Department of Agriculture, from the General Land Office, Geological Survey, and Reclamation Service in the Department of the Interior, from the Federal Farm Board and the Federal Farm Loan Board, and five from the Association of Land-Grant Colleges and Universities, the latter so chosen as to represent our different agricultural regions. The members of this committee were appointed by the executive officers of the agencies represented.

The National Land-Use Planning Committee undertook to study the problems of land planning from the viewpoint of both present and future use. In order to obtain the best technical judgment and experience, it established twelve technical advisory committees. Each of these was composed of fifteen to twenty members from the staffs of various Federal agencies, and about an equal number of corresponding members in the field. The total number

of persons coöperating was about three hundred. The list of the twelve advisory committees follows: (1) Adjustment in Submarginal Areas; (2) Adjustment and Reorganization in Better Farming Areas; (3) Land Inventories and Land Classification; (4) Agriculture Outlook; (5) Forest, Park, Recreation, and Wild Life Preservation Areas; (6) Agriculture Credit; (7) Adjustment and Reorganization in Taxation in Relation to Land Use; (8) Oil, Gas and other Mineral Rights Underlying Farm Lands; (9) Public Range Policy; (10) Reclamation, Drainage, and Irrigation Policies; (11) Control and Direction of Land Settlement; (12) Land Value and Valuation.

National Advisory and Legislative Committee on Land Use.—The second committee created was the National Advisory and Legislative Committee on Land Use, composed of twenty-five members representing the various farmer organizations, the Agricultural Editors' Association, the American Bankers' Association, the American Railway Development Association, and the National Association of Commissioners and Secretaries of Agriculture. This committee was established to interest and inform public opinion regarding problems of land use and to determine practicable procedure in accomplishing desirable changes. Out of this and subsequent Federal action developed the State land utilization conferences mentioned later for New Jersey and Missouri and other special conferences yet to be discussed.

The two committees worked in close coöperation. Nine publications were issued (49) between June, 1932, and November, 1933. Of these, the first four and the sixth were issued by the two committees jointly, and the other four by the National Land-Use Planning Committee alone. In November, 1933, the latter committee recommended that it cease to operate as an organized agency, owing to the creation of new Federal agencies charged with the administration of problems in this field (49—9).

National Planning Board

The Federal Emergency Administration of Public Works, commonly called the Public Works Administration (PWA), was created by an Act of Congress approved on June 16, 1933. The act provided, among other things, for a National Planning Board. It

was composed of three persons not connected with other official agencies, and held its first meeting on July 30, 1933. The purpose of the Board was to advise and assist the Public Works Administration in the preparation of a comprehensive program of planning for public works. This assistance was rendered along three separate lines. First was the preparation and development of comprehensive and coördinated plans for regional areas, in coöperation with national, regional, State, and local agencies. Second, these plans were to be based upon surveys and research on various social and economic trends, including population, land uses, natural resources, etc. In the third place, the Board was to undertake an analysis of projects, in order to prevent duplication and overlapping and to obtain the maximum coöperation and coördination of effort among the various agencies of the Federal, State, and local governments.

There were appointed also, in each State, a State Advisory Board and a State Engineer who was the executive secretary of his board. The United States was divided into twelve more or less natural Planning Districts, and a Regional Advisor appointed for each, his duties being to correlate the individual State plans on a regional basis. These State boards and engineers, and the regional advisors, were a part of the Federal setup and should not be confused with the State and regional planning boards discussed later on.

The National Planning Board held a series of meetings throughout the country for the stimulation of regional and State interest. It also fostered the development of State and regional planning boards comparable to its own State advisory boards and regional advisors. Some forty of the States created such boards through appointment by the governor, containing representatives of State agencies concerned with some or all of such enterprises as agriculture, conservation, highways and other public works, education, or public health, etc., in addition to members having no official connections. If the State planning boards met certain minimum requirements of the National Planning Board, the latter provided at its own expense a State Planning Consultant to assist the State board. The governors also were asked to agree to appoint a State representative on a regional planning board, if such was formed.

The National Planning Board also helped to coördinate the ac-

tivities of the State and regional planning boards with those of the Public Works Administration and the Federal Emergency Relief Administration. The National Planning Board had issued a series of thirteen *Circular Letters* (119) before it was superseded by the National Resources Board on June 30, 1934.

Land Planning Committee.—For land-planning purposes, the National Planning Board organized a Land Planning Committee, consisting of representatives of different agencies in the Departments of Agriculture and the Interior, the Surplus Relief Corporation, and the National Planning Board itself. The function of this committee was to coordinate the land-planning programs of the various Federal agencies. For this purpose, the committee held a series of meetings during the winter of 1933-34 to consider the problems of submarginal agricultural areas, reclamation projects, grazing areas, and future homesteading of the public domain. With the creation of the National Resources Board, this committee, with some changes in personnel, became the Land-Use Planning Committee of that organization.

National Resources Board

On June 30, 1934, there was established, by Executive Order No. 6777, the National Resources Board, consisting of the Secretaries of the Federal Departments of the Interior (chairman), War, Agriculture, Commerce, and Labor, and the Administrator of Emergency Relief (FERA). The three members of the older National Planning Board, also, were made members of the new Board, to act as an advisory committee. The National Resources Board succeeds both the National Planning Board of the Public Works Administration and the President's Committee on National Land Problems, created by Executive Order No. 6693. The work of the National Resources Board has been financed by a special fund of \$100,000 from the Public Works Administration plus the unexpended balances of the National Planning Board, both of which were made available through the executive order creating the Board.

The functions of the Board, as stated, were to prepare and present to the President a program and plan of procedure dealing with the physical, social, governmental, and economic aspects of public

policies for the development and use of land, water, and other natural resources. The program planned was to include the co-ordination of projects of Federal, State, and local governments, and the proper division of responsibility and the fair division of costs among the several governmental authorities. The Board has reduced the number of planning districts in the United States from twelve, as established by the National Planning Board, to eleven. The Board was required to submit a report on land and water use on or before December 1, 1934. It has already issued *Bulletins* (120) and *Circulars* (121).

Land Section.—The work of the Board was organized as sections of its Technical Committee. The Land Section was composed of the land-planning committee of the former national planning board and continues under the direction of the chief of the Division of Land Economics in the Federal Bureau of Agricultural Economics. Its field staff consists of forty or more land-planning consultants, working in collaboration with the several State planning boards. In addition, regional land consultants were appointed to work with the planning-district chairmen and the Agricultural Adjustment Administration regional directors and to coördinate the work of the State land-planning consultants.

The Land Section of the Technical Committee promptly made co-operative arrangements with all Bureaus of the Federal Departments of Agriculture and the Interior, concerned in any way with land administration and use, to make information in the Bureau records available to the Board, both through the loan of Bureau personnel and the temporary assignment of Board employees to work on data in the Bureaus concerned.

Committee on National Land Problems

Under Executive Order No. 6693, dated April 28, 1934, the President created a Committee on National Land Problems, composed of the Secretaries of the Interior and Agriculture and the Federal Emergency Relief Administrator, or their representatives. The committee was directed to undertake a comprehensive survey of our national land problems, for the purpose of improving practices, better balancing the agricultural program, aiding in solving the human problem of land use, and developing a national land

program. Before much could be accomplished the committee was abolished and its work taken over by the National Resources Board, as noted above.

National Resources Committee

The National Resources Board was changed to the National Resources Committee by Executive Order No. 7065, dated June 7, 1935. The National Resources Committee has issued numerous publications, many concerned with land resources, in an unnumbered quarto series. Many of these represent investigations begun by its predecessor boards.

Science Advisory Board

A Science Advisory Board was created by the President under Executive Order No. 6238 of July 31, 1933, amended later by Executive Order No. 6725 of May 28, 1934. It consisted of fifteen members representing official and nonofficial scientific agencies, including the National Academy of Sciences, the National Research Council, the New York State Department of Health, State universities, private universities, other scientific institutions, and some commercial corporations. Several committees were appointed by the Board, acting through the National Academy of Sciences and the National Research Council, both official agencies.

Committee on Land Classification and Land Use.—Among these committees was one on Land Classification and Land Use, on which the Universities of California and Wisconsin were represented. Its purpose was to study and evaluate the scientific data available upon which to base a land-planning program, and thereby to ascertain any omitted fields. It has in preparation a series of reports.

Surplus Relief Corporation, Submarginal Land Division

The Surplus Relief Corporation, a subsidiary of the Federal Emergency Relief Corporation, was allotted \$25,000,000 from the funds of the Public Works Administration in order to purchase submarginal agricultural areas and retire them from crop and livestock production. To this end, it created the Submarginal Land Committee to formulate policies for its Division of Submarginal Land. The membership of the committee consisted of representatives from the Federal Emergency Relief Administration, from

the Agricultural Adjustment Administration in the Department of Agriculture, and from the Department of the Interior. Later, this Division and its committee were superseded by the Land Program Division of the Federal Emergency Relief Administration. The Program Planning Division of the Agricultural Adjustment Administration continues to cooperate in this work.

Recent Progress in Planning

The discussion just concluded on the various and successive official planning agencies might leave the impression that one agency after another had been created and later abolished, and that little progress had been made. The facts are quite the reverse. The changes have been mostly in the administrative and directive agencies, and even there they have been more nearly changes of name and affiliation than changes in scope and objective. The major administrative and research agencies concerned with land problems, both in the Federal government and in the States, have changed scarcely at all, and their work has gone steadily forward. The official and cooperating personnel of the directive agencies has changed relatively little, in spite of the successive changes in organization, name, and affiliation.

A summary of the history and activities of the special and permanent Federal agencies concerned with land-use planning was issued (120—A—3) by the National Resources Board on August 15, 1934. The status and personnel of State planning boards and regional planning commissions was issued by the National Resources Board (121—2) on August 23, 1934. It showed forty-two State planning boards and two regional planning commissions, namely, New England and the Pacific Northwest. It listed also the Federally appointed district chairmen and consultants, there being district chairmen in eight out of eleven districts, and regional consultants in all of them, as well as State consultants in the States themselves.

State conferences.—Following the National Conference on Land Utilization in 1932, State conferences were held in Kansas, Minnesota, Missouri, and New Jersey, in which various Federal and State agencies cooperated in presenting the problems. A New Jersey land-use conference was held at the College of Agriculture of Rutgers University in December, 1932, with representatives from the

Federal Division of Land Economics, the Federal Bureau of Chemistry and Soils, and the New Jersey State Department of Conservation taking part (55—552). In February of 1933, a first Missouri conference on land utilization was held at the College of Agriculture of the University of Missouri. Besides the University of Missouri, representatives of other State agencies, of the agricultural colleges of adjacent States, and of the Federal Land Banks and the Federal Forest Service took part in the program. Proceedings were published by the Missouri Station (45—323).

Regional conferences.—The Pacific Northwest Regional Planning Commission, covering Idaho, Oregon, and Washington, held a three-day planning conference at Portland, Oregon, in March, 1934, in which Montana also was included. At least eight papers were devoted to land-use planning, as indicated by the published proceedings (65) covering 131 pages. During the meeting of the American Association for the Advancement of Science at the University of California in Berkeley in June, 1934, a three-day land-use planning conference was held by Sections K (Economics) and O (Agriculture) and the Western Farm Economics Association, and eighteen papers on this subject were presented. As an aftermath of this conference, the University of California Bureau of Public Administration and Division of Agricultural Economics and the California Forest and Range Experiment Station of the Federal Forest Service coöperated with the California Chamber of Commerce in arranging an eleven-week radio program on land-use planning (9), in which other Federal and State agencies besides those named took part. Section O (Agriculture) of the American Association for the Advancement of Science also sponsored a one-day discussion of the general subject of agricultural planning, including land-use planning, at the regular winter meeting of the Association at Pittsburgh in December, 1934.

Recent research results.—The Federal Division of Land Economics, in coöperation with the Division of Soil Survey of the Federal Bureau of Chemistry and Soils, began in 1932 the classification and rating of the lands of the United States on the basis of productivity. In 1933, this tentative classification was completed in seventeen States and was under way in seven others. The Federal Division of Land Economics has been officially represented also on

many of the committees and boards named above and has prepared abundant material on the subject for others.

In several States, research on land utilization from the new standpoint of coordinated planning is progressing rapidly. Some of the studies already presented for specific States, as for Vermont, Wisconsin, Kentucky, West Virginia, and Washington, belong to this category. A most conspicuous recent example is presented by California.

A comprehensive survey of the utilization of land in El Dorado County, California, was published by the Experiment Station (5—572) in 1934. One of the first of the new land-use planning studies, it is the result of a cooperative investigation by the California Forest and Range Experiment Station of the U. S. Forest Service and the Division of Agricultural Economics of the University of California College of Agriculture, and was published under joint authorship. Acknowledgment was made of cooperation in technical problems received from the Station (i.e. the College) Divisions of Forestry and Soil Technology. This study is one of the first looking toward the best possible utilization of such marginal lands, the stabilization of decaying communities, and the many other factors which are joint problems of the fields of land utilization and rural sociology. In 1935, the Bureau of Public Administration of the University of California issued a bibliography (10) on land utilization, and the Giannini Foundation of Agricultural Economics of this University published (6) a list of references relating to land economics and the present national land policy for the period 1933 to 1934.

The publications listed in the Literature Cited at the end of this chapter which have been cited in this section on Land Economics are Nos. 5, 6, 9, 10, 11, 12, 19, 26, 29, 32, 38, 45, 48, 49, 50, 54, 55, 57, 61, 65, 66, 72, 74, 86, 89, 90, 91, 94, 96, 98, 99, 100, 124, 125, 128, 131, and 133.

6. AGRICULTURAL FINANCE

OFFICIAL INTEREST in the varied problems of agricultural finance was created by the increasing disparity between agriculture and industry which was part of the general economic change in progress in this country at the turn of the century.

Major official attention has been given to the pressing and intricate problems of agricultural credit and farm mortgages, and it is in this field that most of the activities are found and most of the coöperation has developed. Early attention was given, also, to agricultural insurance, including farmers' mutual insurance companies. Since the beginning of the agricultural depression in 1921, increasing study has been given to taxation. A discussion of the status of these three financial interests of the farmer—credit, insurance, taxation—was published by the Federal Division of Agricultural Finance (96—1924:185) in 1925.

AGRICULTURAL CREDIT

Financial credits to agriculture fall naturally into three classes, namely, long-term or mortgage credit, intermediate credit, and short-term or production credit. Formerly all credit was supplied by private agencies, mostly banks, investment companies, and merchants. Economic difficulties in agriculture caused the entrance of the Federal government into the financing of farm operations. Thereupon coöperation of official agencies began to develop both in investigation and in administration. Some States also have extended official credit to agriculture.

Official agencies and activities may be classified as permanent or as temporary or "emergency" in character. In the former belong the Federal Farm Loan Board, the Federal Farm Board, the Reconstruction Finance Corporation, and the Farm Credit Administration, as well as the operations of the Federal Warehouse Act. To the temporary class belong the War Finance Corporation, which made emergency loans during the World War; the various crop and livestock production loans of the U. S. Department of Agriculture to sufferers from drought, flood, and hurricane injury; and some recent work of the Agricultural Adjustment Administration.

Early in the present century, farmers began to find it harder and harder to get long-term credit or to finance it at interest rates they could afford to pay. This brought about wide public discussion of rural credit and finally a Congressional investigation. An account of European systems of rural coöperative credit, summarized from publications of the International Institute of Agriculture, in which the United States Government shares, was published

by the United States Senate in 1912 (83). This was followed by a discussion of the adaptation of the European system to the needs of American farmers (80).

A United States Commission was authorized by the Federal Congress to investigate coöperative land-mortgage banks and rural credit unions and similar organizations in Europe, and their report on agricultural credit (81) was published by the Senate in 1914. Thereafter, joint hearings on rural credits were held by the subcommittees of the House and Senate Banking and Currency Committees charged with investigating rural credits. These joint hearings were published in twenty-three parts (84), separately paged but aggregating some thousand pages. This investigation and discussion of rural credit institutions in Europe was followed by proposals for legislation in the United States Congress culminating in the passage of the Federal Farm Loan Act (76; 82) approved July 17, 1916.

The Federal Department of Agriculture coöperated extensively in the investigation, the hearings, and the drafting of the proposed legislation, through a Section of Farm Financial Relations in its Office of Markets and Rural Organization. Its study of the cost and sources of farm mortgage loans in the United States (86—384) was used for the information of Congress and was published almost simultaneously with the passage of the Act.

Federal Farm Loan Board and Bureau

The Federal Farm Loan Act of 1916 created a Federal Farm Loan Board (18) which supervised the Federal Land Banks and the Joint-Stock Land Banks through a Federal Farm Loan Bureau in the Treasury Department from 1916 to 1933, when the Farm Credit Administration was established. From 1923, it supervised the Intermediate Credit Banks also.

Federal Land Banks.—The Federal Farm Loan Board was required to establish a series of Federal Land Banks distributed in twelve districts throughout the country. The act provided also for National Farm Loan Associations, which are borrower-owned corporations chartered by the Board. The Federal Land Banks make loans, not to individual farmers, but only to members of these Associations. The borrowing farmer member subscribes 5 per cent

of his loan in stock of the Association and the Association in turn subscribes an equal amount of stock in the Federal Land Bank financing the loan. The Associations thus are organized on a co-operative principle, for they soon became the owners of the capital stock of the Land Banks themselves. These in turn are coöperative, since each has responsibility not only for its own farm-loan obligations but also for those of the eleven other Land Banks. In 1931 and 1932, there were approximately 4650 National Farm Loan Associations, or approximately one and a half associations for each county in the United States.

Joint-Stock Land Banks.—The Federal Farm Loan Act permitted the formation of Joint-Stock Land Banks by not less than ten persons, for the purpose of loaning on farm-mortgage securities and issuing farm-loan bonds, under charter by the Federal Farm Loan Board. Each bank is responsible for its own obligations only, and the capital stock is owned by the individual members. At the close of 1932, only forty-six banks remained out of more than eighty chartered, and they are being liquidated under the act creating the Farm Credit Administration.

Federal Intermediate Credit Banks.—As the Federal Land Banks and Joint-Stock Land Banks did not furnish intermediate credit, agitation for additional legislation was continued. The Federal Division of Farm Management and Farm Economics assisted by making credit surveys and publishing on the credit association as agency for rural short-time credit (91—197); on farm-mortgage loans by banks, insurance companies, and other agencies (86—1047); and on bank loans to farmers on personal and collateral security (86—1048). In 1923, partly as a result of these studies, an Agricultural Credit Act was passed which provided for Federal Intermediate Credit Banks under the supervision of the Federal Farm Loan Board and distributed in the twelve Federal Land Bank Districts. They have the same directors and executive officers as the Federal Land Banks, and occupy the same buildings. These Intermediate Credit Banks discount eligible paper for agricultural credit corporations, livestock loan companies, and State and National Banks, and also make loans to coöperative marketing associations on the security of warehouse receipts or shipping documents covering most staple agricultural products up to 75 per cent

of their market value. In 1925, the Federal Division of Agricultural Finance began a general survey of agricultural credit corporations organized under the Agricultural Credits Act of 1923, in order to ascertain the factors of their success and the factors of failure.

Coöperation from other Federal and State agencies.—In 1919, the Section of Farm Financial Relations was transferred from the Bureau of Markets to the Office of Farm Management and Farm Economics, and on July 1, 1922, it became the Division of Agricultural Finance in the Federal Bureau of Agricultural Economics. This unit has worked widely with the Federal Farm Loan Board in supplying information to farmers concerning the Federal Land Banks and especially with reference to the organization of local loan associations. In this coöperation it informed farmers on how they could benefit under the act (87—792) and, in 1921, discussed buying farms with Land Bank loans (86—968), based on questionnaires sent to borrowers whose names were furnished by the Board.

In 1925, the Division of Agricultural Finance began a general survey of the agricultural credit corporations organized under the Agricultural Credits Act of 1923, in order to ascertain the factors of success and failure. In 1927, the Division published a brief summary of the farm-credit situation as influenced by these three types of banks (96—1926:285). A final summary of the credit situation, consisting of a series of short articles under the title "How to Use Farm Credit" was prepared by the Federal Division of Agricultural Finance (96—1932:501) in 1932.

Similar assistance in giving information to farmers has been rendered by the departments of agricultural economics and the agricultural extension services of the various State colleges of agriculture, some of them, as for example Illinois (27—259) in 1922 and Texas (73—330) in 1925, publishing on the Federal farm-loan system. Soils experts from both Federal and State agencies have assisted the land appraisers of the Federal Farm Loan Board in establishing the value of farm lands.

Coöperation given to other agricultural agencies.—As shown above, the Federal Farm Loan Board has developed the Federal Land Banks as a great coöperative project, and has received the

assistance of many agricultural agencies in furthering this enterprise. The Federal Farm Loan Board itself also has coöperated with other agricultural agencies in giving publicity to matters of general agricultural interest and improvement. The Federal Land Banks have encouraged the formation of farmers' coöperative associations for buying and selling commodities, breeding livestock, and conducting creameries, cheese factories, milk condensing stations, and potato warehouses, and for other enterprises. They have systematically encouraged diversification of crops in single-crop areas, especially where drought has caused acute distress. In the South, where soil erosion is a major farm problem, the Federal Land Banks have insisted on protective terracing as one of the conditions prerequisite to a loan.

The three Federal Land Banks situated in Kansas, Minnesota, and Washington, acted as financial agents for the government in the application of a special emergency fund for drought relief in 1918, in coöperation with the Federal Department of Agriculture. The Federal Intermediate Credit Banks of New Orleans and St. Louis coöperated with other Federal agencies in plans and action for the rehabilitation of flood sufferers in the Mississippi Valley during 1927. Land appraisers of the Federal Farm Loan Board have coöperated with other Federal and State agencies in demonstrations of land valuation by soil classification and other technical criterions.

In California, the Federal Land Bank of Berkeley coöperated with the Division of Agricultural Economics at the Experiment Station in a study of the problem of securing a closer relation between agricultural development and irrigation construction—a study which was published by the station (5—435) under joint authorship in 1927. The California State Department of Agriculture, in 1929, published an address on "Agricultural Credit in California" (7—18:144) by the president of the Federal Intermediate Credit Bank of Berkeley.

United States Warehouse Act

The United States Warehouse Act, passed in August, 1916, did not provide for the granting of credit to farmers by the official agency administering this act, which now is the Division of Warehousing

in the Federal Bureau of Agricultural Economics. It did provide, however, a system of classing and grading certain agricultural commodities so that their quality and value might be ascertained by credit agencies. As a result, official warehouse receipts became accepted as collateral for loans on the value of the commodities represented when stored in licensed warehouses.

In 1918 and 1919, large loans were made by the War Finance Corporation on the security of Federal warehouse receipts. From 1920 onward, the Federal Reserve Banks in different districts called the attention of member banks to the value of this security. In 1923, the Federal Farm Loan Board provided that the Federal Intermediate Credit Banks might make loans to coöperative marketing associations on the pledge of such warehouse receipts, up to 75 per cent of the commodity values. Under an amendment of 1932, they are authorized also to accept drafts or bills of exchange drawn by such coöperative marketing associations when secured by warehouse receipts.

In 1927, the Division of Warehousing summarized credit made available to farmers through the United States Warehouse Act (96—1926 :287), and, in 1928, it presented the benefits to canners through efficient financing under the act (96—1927 :679).

War Finance Corporation

The War Finance Corporation was created by an Act of Congress approved April 5, 1918. It was authorized to make advances, from a capital stock of \$500,000,000 subscribed by the United States Treasury, to financial institutions whose operations were held to contribute to the prosecution of the war. Under this authorization, it loaned money to agencies financing agricultural production, especially the production of livestock, and, under later authorization, assisted in the exportation of agricultural products to foreign countries.

In May, 1920, the activities of the Corporation were suspended. By joint resolution on January 4, 1921, however, Congress directed that the Corporation resume its activities for the relief of the agricultural depression. Under this authorization, the Corporation began a general financing of agricultural marketing through coöperative associations. Under an Agricultural Credits Act of August

24, 1921, the Corporation was authorized to expand its operations in this field, including loans to livestock-loan companies and co-operative marketing associations of producers. The act provided that the Corporation should cease active functioning on July 1, 1922, but its term finally was set at December 31, 1924, since which time its affairs gradually have been liquidated (122).

During the active life of the War Finance Corporation, its agencies were given the same coöperation from the Departmental and field forces of the U. S. Department of Agriculture and the State colleges of agriculture, including the Federal-State coöperative Extension Service, as has been given to all the other official agencies concerned with the providing of agricultural credit.

U. S. Department of Agriculture

The Federal Department of Agriculture has had two separate activities in the provision of credit to farmers. The first was with relief loans for crop production in distressed areas. The second is found in the program of the Agricultural Adjustment Administration.

Seed and crop-production loans.—Since 1917, the Federal Department of Agriculture has been engaged in certain emergency relief activities for distressed farmers, most of which have involved the making of loans from funds especially appropriated for that purpose. In 1917 and 1918, there was severe drought in portions of the Great Plains, and also in the Pacific Northwest. At first relief consisted chiefly in Federal, State, and commercial coöperation in moving livestock from the distressed areas. In July of 1918, however, the President of the United States made \$5,000,000 of his emergency funds for stimulating agriculture available to the Agriculture and Treasury Departments for relief-loan purposes. The Federal Land Banks of the three districts affected were designated as financial agents of the government to make and collect the loans. The most extensive and effective coöperation was established between these Federal agencies and various State agencies, including councils of defense, agricultural colleges, departments of agriculture, and others. Loans were made for the purchase of seed wheat, and only to farmers who had suffered the loss of two successive crops. The drought continued with greater severity in 1919

and the following Congress authorized the expenditure of still larger funds for this and allied purposes of agricultural production.

In the eleven years from 1921 to 1931, similar loans were authorized in eight different years for the relief of sufferers from drought in the West, from floods in the southern States and in the Mississippi Valley, and from hurricanes in the southeastern States and Puerto Rico. These loans were made from special appropriations to the Department of Agriculture. During 1932 and 1933, they were made from funds advanced by the Reconstruction Finance Corporation to the Department of Agriculture under the provisions of Section 2 of the Reconstruction Finance Corporation Act of January 22, 1932.

So severe and extensive was the general drought of 1930 that a conference of State governors was called by the President. It was agreed that a Federal committee representing all agencies concerned should be organized and that State drought committees, composed of State officials and others, should be set up. County committees were organized also in all counties seriously affected.

A National Advisory Loan Committee was appointed by the Secretary of Agriculture to assist in administering the stock-purchase fund, and similar advisory committees were appointed by the national committee and the Secretary in twenty-two drought-stricken States. The national committee devoted much effort to an educational campaign (109) including press releases, radio broadcasting, and other methods. Five field offices were established, complete State and local official coöperation was arranged, and the work was carried forward rapidly.

In 1924, the Federal Division of Agricultural Finance was to make a report on the experience of the Federal government with direct loans to farmers on the basis of the record of seed loans made. In 1933, under the auspices of the National Land-Use Planning Committee, the Division made an analysis of Federal seed-loan policies. The Seed-Loan Office, established when the first loans were made, and the Crop-Production Loan Office, established in 1930, both were transferred to the Farm Credit Administration in 1933, by Executive Order.

Agricultural Adjustment Administration. — The Agricultural

Adjustment Act of May 12, 1933, was in part a successor to the Agricultural Marketing Act of 1929, under which the Federal Farm Board had been created. The Board was abolished by the executive order of March 27, 1933, effective on May 27, and most of its functions transferred to the Farm Credit Administration.

The Agricultural Adjustment Act was administered by the Agricultural Adjustment Administration under the U. S. Department of Agriculture. The declared purpose of the act was to establish and maintain such balance between agricultural production and the consumption of agricultural commodities as would give to agricultural products the purchasing power of a prewar base period and at the same time protect consumers by such adjustment of farm production that the percentage of consumer retail expenditure returned to farmers should not be larger than that of the base period. A comprehensive discussion of the economic bases for the Agricultural Adjustment Act was issued by the Department (14) as an unnumbered publication in December, 1933.

The act gave to the Secretary of Agriculture general power to obtain reductions in acreage or production for market, or both, of certain basic agricultural commodities through agreements with producers or by other voluntary methods. The basic commodities named by the act were wheat, cotton, field corn, hogs, rice, tobacco, and milk and its products. Rental or benefit payments were authorized on that part of production required for domestic consumption, in return for agreed-upon reductions in production. The Reconstruction Finance Corporation was authorized to advance and to loan funds to the Secretary for specified purposes.

The act also provided for a processing tax to be levied on the first domestic processing of the commodity, the tax to be paid by the processor. This tax was to equal the difference between the current average commodity farm price and the fair exchange value of the commodity, which was its parity during the base period. This tax, collected by the Bureau of Internal Revenue of the Treasury Department, was appropriated to the Secretary of Agriculture to aid in carrying the costs of the adjustment program. The Secretaries of Agriculture and the Treasury were empowered to make regulations to enforce the act.

The provisions of the act required contacts with millions of

farmers producing the basic commodities. Exceedingly prompt organization and operation were necessary in order to make the act effective in the season of 1933. In the actual work in the field, the nation-wide coöperative Federal-State Extension Service, with its large and thoroughly organized force of county agents, was of the greatest possible service in putting over the enormous program (97:17). The work of the State and county committees, and of the reviewing committees which function in Washington, required the services of some State and local, as well as Federal officials, in working out the schedules of acreage and product reduction. So important were the relations of the State colleges of agriculture that the Association of Land-Grant Colleges and Universities arranged for a series of three papers (4—47(1933):172—78) on fitting the extension program to the needs of the adjustment program, to be presented at its forty-seventh annual meeting in 1933. One discussion was by the Federal Extension Director, one by a State Extension Director, and the third by a Station Director. At the same time, the work of the Agricultural Adjustment Administration was presented (4—47(1933):100—103) by its executive.

The Farm Credit Administration coöperated by refusing to make production credit available for more than 70 per cent of the 1932 acreage of ten leading crops.

In organizing the various commodity divisions of the Administration it was necessary to obtain qualified experts from outside the Federal service, especially from the State colleges of agriculture. As it was not expected that the setup would be permanent, these institutions coöperated in releasing specialists temporarily for this purpose. In the first report of the Agricultural Adjustment Administration, a document of nearly four hundred pages covering the period to February, 1934, credit is given to many other units of the Federal Department of Agriculture for supplying contained material (97).

On January 6, 1936, a decision of the Supreme Court of the United States invalidated the Agricultural Adjustment Act, primarily on the ground that it attempted to exercise control over agricultural production, which the Court held to be a local affair. On February 29, 1936, there was approved the "Soil Conservation and Domestic Allotment Act" as an amendment to the Agricul-

tural Adjustment Act. The stated objectives of the new act were: (1) preserving and improving of soil fertility, (2) promoting economic land use, (3) diminishing the effects of soil erosion, (4) protecting rivers and harbors from soil silting, and (5) reestablishing parity between agricultural and nonagricultural income per capita.

The Secretary of Agriculture was authorized to cooperate with the several States by making grants of funds to such States as designated satisfactory administrative agencies and submitted approvable programs designed to achieve the objectives of the act.

The Administration has not established classified series of publications, such as bulletins, circulars, annual reports, etc., as most Federal bureaus have done. Instead it has one numbered but unnamed series of general publications designated by the letter "G" and a serial number (97). In addition, it has issued some general publications without numbers and a series of special commodity publications concerned with each of the major agricultural commodities.

The Federal Farm Board

The creation of the Federal Farm Board in 1929 was the culmination of a ten-year effort. With the end of the World War began the rapid deflation of agriculture. By 1920, the industry was distressed and by 1921 conditions had become acute. As an emergency measure, the agricultural financing operations of the War Finance Corporation were revived in 1921.

Proposed legislation for agricultural relief.—During the ten-year period from 1920 onward, a long series of conferences and inquiries took place and many acts of legislation for the relief of agriculture were proposed. Large numbers of hearings before the committees on agriculture in the two houses of Congress were held and the proceedings published, and many reports on pending legislation issued by the House and Senate. An enormous volume of literature on these agricultural relief measures, especially the "McNary-Haugen" bills, appeared in magazines and journals of all kinds.

The series started with various bills for reviving the agricultural functions of the War Finance Corporation. These were made the subject of Congressional hearings and reports during 1920 and

1921, and the bill was passed in 1921. The Federal Congress created a Joint Commission of Agricultural Inquiry in 1921. It held far-reaching hearings during July and August, which resulted in the publication, in 1922, of three volumes totaling more than 2350 pages (79). These were followed, also in 1922, by its voluminous report of approximately 1350 pages (78) in four parts, covering respectively the agricultural crisis and causes, credit, transportation, and marketing and distribution.

The Federal Bureau of Agricultural Economics published a selected bibliography on price fixing by governments from 424 B. C. to 1926 A. D. (99—18) in 1926, another on the control of production of agricultural products by governments (99—23) in 1927, and finally a selected and annotated bibliography on agricultural relief (99—27) in 1929.

The Agricultural Marketing Act.—The Agricultural Marketing Act of June 15, 1929, created a Federal Farm Board (15) of eight members, with the Secretary of the U. S. Department of Agriculture as an ex-officio member. It was designed to promote the effective merchandising of agricultural commodities in order to bring farming into economic equality with other industries. This result was to be accomplished by minimizing speculation, preventing wasteful methods of distribution, preventing and controlling surpluses, and promoting the establishment and financing of producers' marketing organizations (16; 17).

The Division of Coöperative Marketing in the Federal Bureau of Agricultural Economics was transferred by executive order to the Federal Farm Board on October 1, 1929. The Board received fullest coöperation from the Federal Department of Agriculture, the State agricultural colleges, and the State departments of agriculture and of marketing. The Federal-State Coöperative Agricultural Extension Service, representing both the Federal Department and the State colleges of agriculture, was of great assistance through its system of county agents in educating producers in the purposes and benefits of the Federal Farm Board. The Board in turn permitted the coöperative marketing associations to devote certain of the loan funds to education in coöperation.

The Agricultural Marketing Act provided (Sec. 13) that the Board should coöperate with other Federal executive agencies in

the use of services and facilities in order to avoid preventable expense or duplication of effort. It provided likewise that the Board should indicate through the Secretary of Agriculture any studies needed which were within the province of that Department. Authority also was given to the Board to coöperate with any State or territorial official agency or subdivision. Some coöperative studies were made by the Federal Bureau of Agricultural Economics and the Board.

In 1930, the Division of Agricultural Finance joined the Division of Coöperative Marketing, just transferred to the Board, in a study of the success of five agricultural credit corporations which served as auxiliaries to coöperative cotton-marketing associations. Separate reports were issued on three of the corporations and a consolidated report (89—322) was published in 1932. Problems in financing potato growers on the Eastern Shore of Virginia were studied in 1930 by the two Divisions. This was continued to 1933, and included a comparative study of country banking practice in that area as compared with Iowa. In 1933, studies were made of agricultural credit corporations and livestock loan companies in the St. Louis district.

In May, 1933, the Federal Farm Board was abolished and its functions transferred to the then created Farm Credit Administration, discussed later.

Reconstruction Finance Corporation

This corporation was created by the Reconstruction Finance Corporation Act, approved January 22, 1932. It was authorized by law to loan funds to various institutions, including the Federal Land Banks, Joint-Stock Land Banks, and Intermediate Credit Banks. The Farm Loan Commissioner of the Federal Farm Loan Board was made an ex-officio member of its Board of Directors. The Corporation was authorized also to advance funds to the Secretary of Agriculture for the making of crop-production loans to farmers. This was done on a relatively large scale during 1932 and 1933.

In July, 1932, Congress amended the Reconstruction Finance Corporation Act to authorize that corporation to establish a Regional Agricultural Credit Corporation in each of the twelve Fed-

eral Land Bank Districts. These corporations were authorized to make direct loans to farmers and stockmen for agricultural purposes, including crop production and the raising, breeding, fattening, or marketing of livestock.

The Regional Agricultural Credit Corporations were emergency institutions made necessary by the banking crisis of 1932 and 1933. By the Executive Order of March 27, 1933, they were transferred to the Farm Credit Administration, effective as of May 27 of that year. Their place gradually is being taken by the Production Credit Corporations and the affairs of the earlier corporations are being liquidated.

Farm Credit Administration

The Farm Credit Administration, created by Executive Order effective on May 27, 1933, included the Federal Farm Board, the Federal Farm Loan Board and Bureau of the Treasury Department with its Federal Land Banks, Intermediate Credit Banks, and Joint-Stock Land Banks, and finally, the Crop-Production Loan Office and Seed-Loan Office of the Federal Department of Agriculture. In addition, the Administration was directed to establish a Central Bank and twelve Regional Banks for Coöperatives, and to organize twelve Production-Credit Corporations, one such bank and corporation to be situated in each of the twelve Federal Reserve districts.

All other official agencies previously concerned with agricultural credits have coöperated with the Farm Credit Administration. This has been especially true of the Federal Department of Agriculture and the corresponding State agencies. The Secretary of Agriculture immediately requested the Federal-State Agricultural Extension Service to assist in every possible way. By agreement with the Farm Credit Administration, the offices of the county agricultural agents have been used as headquarters for the local representatives of the Farm Credit Administration. In California, the Extension Service promptly published a list of the names of the local agents of the Administration and of the county agents with whom they were quartered, and made this available to farmers throughout the State. A discussion of the Farm Credit Administration and its operation was given by an executive on invitation be-

fore the forty-seventh annual convention of the Association of Land-Grant Colleges and Universities in November, 1933 (4—47 (1933):64—71).

In October, 1933, the Farm Credit Administration suggested to the governors of the several States that they appoint State agricultural advisory committees on the farm-debt adjustments provided for in the Emergency Farm-Mortgage Act. It was suggested further that these committees, with the governor, develop county agricultural advisory committees. As a result of this coöperation, in which other agencies took part, 41 States had created State committees and more than 2100 counties were so equipped, out of some 2500 agricultural counties in the United States, as reported at the meeting of the Western Farm Economics Association in California in June, 1934 (132:136).

In June, 1934, the University of California was host to the meetings of the American Association for the Advancement of Science and affiliated societies, including the Western Farm Economics Association (132), with which the Farm Credit Administration coöperated through the presentation of three papers.

Federal-State Coöperative Investigations

The coöperative investigations by Federal and State agencies include studies of credit facilities and uses, and of mortgage indebtedness.

Farm credit.—The Federal Division of Agricultural Finance in the newly organized Bureau of Agricultural Economics, in 1922, immediately began studies of credit conditions in coöperation with the colleges of agriculture in various States. The first work was done in the southern States. Credit and insurance conditions among farmers were investigated in North Carolina and South Carolina in 1922 and 1923. In 1924, a general study of farm-credit conditions throughout the United States was begun, partly in coöperation with State agencies, to ascertain the volume, sources, costs, terms, and purposes of various classes of credit used by farmers. These data were summarized, interpreted, and published (96—1924:185) in 1925, and a brief synopsis of farm-credit institutions and conditions (96—1926:285) in 1927.

In 1924, several preliminary field surveys were made of credit

conditions in the production and marketing of fruits, vegetables, and livestock in various parts of the country. Part of this material was obtained through informal coöperation with State agencies and most of it used in various Federal publications on commodity marketing.

In the southern States, the coöperative study of farm-credit conditions begun in the Carolinas was extended in 1924 to other States in the cotton belt, including Arkansas, Georgia, Oklahoma, Tennessee, and Texas. In 1927, a special questionnaire inquiry and intensive local studies of all forms of credit used by the farmer were begun coöperatively in the major cotton-growing States. Several of these studies were published by the State Experiment Stations, including Arkansas (3—208), Georgia (22—153), North Carolina (58—270), Oklahoma (62—198), and South Carolina (69—282). In 1930, the Federal agency began preparation of a summary of all the credit studies made in the cotton belt. A final coöperative study in Arkansas, covering the condition of Arkansas banks in 1932 and 1933, published (3—298) in 1934, acknowledged assistance received from the Federal Reserve Board, the Federal Reserve Bank of St. Louis, and the Arkansas State Banking Department.

In 1932, the Cornell University Experiment Station published an analysis of the loaning operations of the Federal Land Bank of Springfield from 1917 to 1929, with assistance acknowledged from its president and the chief appraiser (57—549). In the northern Great Plains, beginning in 1925, a study was made of credit conditions in the range-cattle industry, the study in Montana being in coöperation with the State Agricultural College.

Relatively little coöperation has developed in California in studies of agricultural finance. The Station Division of Agricultural Economics coöperated with the Federal Land Bank of Berkeley in a study of the problem of securing closer relations between agricultural development and irrigation construction, which was published by the Station (5—435) in 1927. A study of the economic problems of California agriculture, including agricultural credit and taxation, made by the Division of Agricultural Economics of the University of California College of Agriculture (5—504) in response to a resolution of the State legislature in 1929, used in-

formation from the Federal Department of Agriculture and other Federal agencies in 1930.

Farm-mortgage indebtedness.—In 1924, the Federal Division of Agricultural Finance surveyed the indebtedness of farmers since 1920, by years and by States, including farm foreclosures in fifteen States in the Middle West. Through coöperation with the Federal Bureau of the Census, statistics on mortgage indebtedness for 1925 were obtained. After these data were available, the Federal Division of Agricultural Finance, in 1928, undertook an analysis of the total farm-mortgage indebtedness of the country and that carried by tenant-operated and manager-operated farms (89—288; 96—1932:912), giving data by States for 1910, 1920, 1925, 1928, and 1930.

Recent studies of farm mortgages and mortgage foreclosures were made in coöperation with certain States in the Middle West. In Iowa (30—156) and Nebraska (51—67) the studies were conducted jointly by the Federal Divisions of Agricultural Finance and Land Economics and the Agricultural Economics Sections of the Experiment Stations. A study by the State Station of farm-mortgage foreclosures in Minnesota (40—293) was coöperative only with the Federal Land Bank of Minneapolis.

In response to a resolution in the Federal House of Representatives, the Division of Agricultural Finance summarized the farm-debt situation for publication by that body (75). Recently, the Division has reviewed the history of past policies and of farm bankruptcies under the National Bankruptcy Act of 1898 and recent amendments thereto.

FARM INSURANCE

Farm insurance may be employed to protect buildings, contents, crops, and livestock as well as automobile liability and farm employers' liability. Buildings and their contents may be insured against fire, lightning, tornadoes, or windstorm damage. Crops may be insured against fire as in the Far West, or hail as in the Middle West, or diseases. Livestock likewise may be insured against these occurrences and also against lightning injury.

Farmers' mutual insurance companies were formed in this country as far back as 1825. They have had an increasingly extensive development in the last fifty years since the general coöperative

movement among farmers was begun. At first they were concerned primarily with affording insurance against fire loss but gradually have added the other types of insurance named above. The Federal Office of Markets and Rural Organization published on these companies (96—1916:421; 86—530 and 786) in 1917 and 1919.

The Section of Farm Financial Relations in the expanded Office of Farm Management and Farm Economics took over this work in 1919 and issued three publications (86—840 and 912; 91—77) in 1920, and a fourth (86—1043) in 1922, with some interbureau coöperation.

In 1922, the Division of Agricultural Finance in the Federal Bureau of Agricultural Economics took over these functions and began studies of insurance and credit conditions in coöperation with the North Carolina and South Carolina Colleges of Agriculture, Texas being added in 1924.

The Division published in 1925 a summary of the status of farm insurance, credit, and taxation (96—1924:239), based on data obtained by the Division and its predecessors from all available sources, including coöperative investigations.

Beginning in 1925, the Federal Division made a second study of the farmers' mutual fire insurance companies, the results, both coöperative and independent, being published (90—54) in 1928. Throughout this period, the Division coöperated with its sister Division of Farm Management, with the Bureau of Chemistry, and with the Division of Agricultural Engineering in the Bureau of Public Roads, in extensive activities looking toward fire prevention on farms.

TAXATION

Little official attention was given to farm taxation by the Federal Bureau of Markets and Rural Organization or by the Office of Farm Management and Farm Economics, in the period from 1914 onward, but in 1922 the Division of Agricultural Finance began an intensive study of the taxation of farm real estate. This covered the taxes levied, capital and assessed value, and gross and net income, with changes in these throughout a period of years. The data were obtained in part from county officials and in part by questionnaires, and certain successive tabulations of data were made by the Federal agency either independently or partly in coöperation

with State and other agencies. From 1925 onward various surveys and annual summaries were prepared, and a selected and annotated bibliography on taxation and the farmer (99—25), covering the period 1900 to 1927, inclusive, was issued in 1928.

Federal-State Coöperation

Two successive series of studies were made by the Federal Division of Agricultural Finance, in coöperation with State agencies, one from 1924 to about 1928, and a second beginning at the conclusion of the first.

Early studies.—In fiscal year 1924, the Division began a series of studies of farm taxation in coöperation with the colleges of agriculture in several States. The study covered the total taxes paid by farmers, the relation of land taxes to rent, and the distribution of the farmers' tax dollar. The coöperation was begun in Kansas, Missouri (46—93), Nebraska, and Texas (73—334), but was expanded rapidly to include Colorado (11—346 and 355), Massachusetts (36—235 and 256), Michigan (39—91), North Dakota, Oklahoma, South Dakota (70—232), and Virginia (125—268) by fiscal year 1927. In this study attention was given also to the need of revision in State tax laws, looking toward a more equitable distribution of the tax burden. The North Dakota study was published by the station (60—203) with assistance acknowledged from the State Department of Public Instruction, Tax Commission, and Highway Commissioner, and from various county officers.

In North Carolina, following conferences between the Federal Bureau of Agricultural Economics, the State College of Agriculture, the State University, and the State Department of Agriculture, a comprehensive study of farm income and taxation was jointly authored by the Federal Division, the Experiment Station, and the State Tax Commission, and published by the Commission and reprinted by the Station (58—267) in 1929. A later study by the same three agencies was published by the Station (59—43) in 1933.

In Wisconsin, during 1927 and 1928, a special study was made of the use and taxation of land in Lincoln County by the Departments of Agricultural Economics and Agricultural Engineering of the College of Agriculture (133—406) in coöperation with the Fed-

eral Forest Service and with assistance from the Forest Taxation Inquiry.

After these studies were completed, the Federal Division of Agricultural Finance summarized and published the results of the six or seven years of research in farm taxation (89—172), including studies made in coöperation with these States and, also, research conducted independently by State agricultural experiment stations.

Recent studies.—With the completion of this first series, the Federal Division of Agricultural Finance, in 1928, began new studies in coöperation with State agencies in Delaware, Iowa, Louisiana (33—231, Part 1, Part 2), Montana (47—286), New Jersey, North Carolina (59—43), South Carolina, Washington, and Wisconsin. The coöperative studies in Louisiana, Montana, and Wisconsin, described below, as well as others in Kentucky and Minnesota, were investigations of both local government and farm taxes. The Iowa study was in coöperation with the State Tax Commission. The New Jersey coöperation (55—532) included the State Department of Agriculture also, with assistance from the State Bureau of Municipal Accounts, the State Tax Board, county boards, and local tax officials. A later New Jersey study was conducted under the same coöperation (55—542).

Intrastate Coöperation

In Connecticut, the Departments of Economics and Farm Management of the (Storrs) Agricultural College (12—166) received assistance from the State Tax Department. In Maine, the Department of Agricultural Economics of the University (34—366) acknowledged assistance from State officials, tax collectors, and town selectmen. In Maryland, the governor, in 1931, appointed a Tax Survey Commission to report findings and recommendations to the legislature, these being published by the State Station (35—339). In South Carolina, the governor called a conference on taxation in 1925 and later appointed a committee to study the State taxation system, which was done in coöperation with the Experiment Station (69—231), the Station author being secretary of both the conference on taxation and the research committee of seventeen. A Pennsylvania study of the cost of county government, published

by the State Station (66—297), acknowledged splendid coöperation by county officials.

The publications listed in the Literature Cited at the end of this chapter which have been cited in this section on Agricultural Finance are Nos. 3, 4, 5, 7, 11, 12, 14, 15, 16, 17, 18, 22, 27, 30, 33, 34, 35, 36, 39, 40, 46, 47, 51, 55, 57, 58, 59, 60, 62, 66, 69, 70, 73, 75, 76, 78, 79, 80, 81, 82, 83, 84, 86, 87, 89, 90, 91, 96, 97, 99, 109, 122, 125, 132, and 133.

7. RURAL SOCIOLOGY

AS A FIELD OF STUDY, rural sociology is one of the newest and least tangible of the subjects embraced in agricultural economics. Other more definitely organized subjects, such as farm management, coöperative marketing, land economics, home economics, and agricultural extension, all come into rural sociology to a greater or lesser extent. There are certain divisions of the general subject, however, which are classed definitely as rural sociology by common consent. The close relation between problems of rural sociology and those in the more strictly economic aspects of agriculture is shown by the way the subject was developed in the Federal setup.

HISTORICAL DEVELOPMENT

The Federal Office of Markets, established in 1913, was expanded into the Office of Markets and Rural Organization in 1914, and thereafter gave increasing attention to its newer interest. This interest was maintained in the Federal Bureau of Markets until 1919, when its work was organized as a Section of Rural Life Studies in the independent Office of Farm Management and Farm Economics. With the creation of the more inclusive Bureau of Agricultural Economics, in 1922, most of the sociological work was consolidated in a new Division of Farm Population and Rural Life, which continues. Certain activities of the coördinate Division of Land Economics, such as those relating to farm labor and wages or ownership and tenancy, are important to rural sociology.

The manner in which the work of many different Federal governmental units has been concerned in rural organization and life is revealed in a discussion published by the Federal Department of Agriculture (96—1915:272A) in 1916. Therein the social contri-

butions made by the Office of Farm Management, the Office of Extension Work in the States Relations Service, the Bureaus of Animal Industry and Plant Industry, and the Office of Public Roads and Rural Engineering, as well as the Office of Markets and Rural Organization, are discussed in some detail. The same can be said of the State organizations, where also the Department of Agricultural Economics usually has been the center of activities. As a matter of fact, the Federal-State Agricultural Extension Service is probably the single strongest force in this field.

Development of Coöperation

From 1914 to 1919, when rural-life studies were conducted by the Federal Office of Markets and Rural Organization, much of the effort was devoted to general studies of rural social organizations, based on efforts being made by other units of the Federal Department of Agriculture, especially those of the Agricultural Extension Service created at that time. The Office coöperated directly, also, with the colleges of agriculture in intensive surveys of rural conditions in selected counties. These included studies of the farm home, the rural community, and rural organizations. Such a survey was made in Orange County, North Carolina, in 1915 and 1916, in coöperation with the University of North Carolina. A similar survey was made in Albemarle County, Virginia, in 1916.

With the transfer of rural-life studies to the Federal Office of Farm Management and Farm Economics in 1919, coöperation was arranged with various State colleges of agriculture where instructors in rural sociology were employed. One of the first studies undertaken covered the differences in social life of communities founded on different types of agriculture, such as dairying, grain growing, and truck farming, to determine if the people and the institutions they established showed any major differences.

In 1922, the newly created Division of Farm Population and Rural Life began a general study of rural institutions, conducted in coöperation with State agencies. The national interest in this subject was shown by increased educational courses offered in rural sociology. Some six hundred American educational institutions, including universities, colleges, normal schools, and theological seminaries, each gave from one to many courses in 1923. Of the



forty-eight State colleges of agriculture, forty offered such courses, and fifteen of them employed full-time instructors. Ten years previously, not more than twenty of the State colleges had offered any instruction in rural sociology.

The Purnell Act, through which the Federal Congress, in 1925, began to expand greatly the Federal funds available to the State agricultural experiment stations, provided expressly that these funds might be used for studies in rural sociology as well as in agricultural economics. This was a great stimulus both to research and to coöperation.

The new Division maintained a small staff in Washington and a large number of coöperative employees located at State colleges of agriculture and State departments of agriculture. These received only a nominal Federal salary but worked in close coöperation with the Division, which endeavored to coördinate the work of Federal and State agencies. In 1927, the Division began to issue a quarterly publication entitled *Farm Population and Rural Life Activities*. In the same year, it was reported that thirty-five coöperative studies were conducted during the year. In 1928, nearly \$100,000 of Purnell Act funds were allocated by twenty-five State stations for sociological research, and the Division coöperated in twenty-eight projects with these State agencies.

In 1928, ten coöperative studies were completed and bulletins containing the results published by the coöperating State agencies. Field work was nearly or quite completed on fourteen other studies. In the same year, the Division gave assistance and supervision to a survey of active research projects in rural sociology, which resulted in the preparation of a valuable monograph. In 1930, the Division established a short course on methods of research in that field, which was attended by sixty men and women from thirty-six different colleges and universities in the United States and Canada (98—1930:70). In the following year, the Division aided the Federal-State Extension Service in holding a conference of extension workers in rural sociology. The coöperation included service on permanent committees to study research needed for an adequate extension program, and assistance in assembling and adapting rural sociological material for use in such programs.

Since 1925, the Federal Bureau of Agricultural Economics has

been publishing bibliographies of the literature of rural sociology. To date six have been issued, as follows: *Literature of Rural Life* (99—3); *Rural Economic Research in the Southern States* (99—10); *Farm Youth* (99—17); *Rural Standards of Living* (99—32); *Advantages and Disadvantages of Country Life* (99—37); and *Part-time Farming* (99—43).

* SOCIAL ASPECTS OF THE RURAL COMMUNITY

One of the most important problems in rural-life studies is the organization of the rural community from the standpoint of economic, educational, social, and civil activities. Much of the preliminary study already discussed was more or less of this nature. From 1919 onward, the Section of Rural Life Studies and its successor, the Division of Farm Population and Rural Life, have engaged actively in coöperative studies in this field with similar units in the State colleges of agriculture. The following examples show the scope and trend.

Among the earliest coöperative surveys of this nature were those with the Iowa Station in 1920 on the social aspects of rural life and farm tenantry in Cedar County (29—217) and with the Montana Station in a social study of Ravalli County (47—160); the New York (Cornell) Station study of social areas in Otsego County (57—422); the Washington Station study of some better things in farm life (128—195); and the West Virginia Station discussion of the rural community at French Creek (130—176): all published between 1921 and 1925.

Recent studies of this character cover coöperation with the Pennsylvania Station in 1927 on the social activities of families in Unionville District of Chester County (66—286), and with the Missouri Station on contacts in a rural community (46—125). From 1927 to 1931, the Department of Rural Social Organization of Cornell University and the Federal Division of Farm Population and Rural Life coöperated in a series of studies of seven counties of central New York, including investigations into communities of Schuyler County (57—524), the social and economic areas of Yates (57—521) and Broome Counties (57—559), and the rural, social, and economic areas of central New York (57—614). Others (57—582, 583, and 584) are discussed later in special subsections,

and all are applied in a discussion of the relation of community areas to town[ship] government in the State of New York (57—555) in 1933.

Community Buildings

The Federal Office of Farm Management and Farm Economics gave attention to rural community building independently from 1919 onward, covering plans (87—1173), organization (87—1192), and uses (87—1274), the last two superseded (87—1622) in 1930. The Federal Division coöperated with the Montana Station Division of Rural Life Studies in an investigation of rural community halls (47—221), published in 1929.

Rural Organizations

The volume of research in rural business and social organizations has not been especially large and the coöperative portion of it still smaller, except in farmers' coöperative marketing organizations, which already have been discussed in the section on Marketing Agricultural Commodities. Therein were discussed several surveys of the attitudes of farmers toward their coöperative organizations, which lie largely in the field of rural sociology. The Divisions of Coöperative Marketing and of Farm Population and Rural Life in the Federal Bureau of Agricultural Economics have shared in several such studies of the social factors of the success or failure of farmers' coöperative organizations. That collaboration was continued after the transfer of the Division of Coöperative Marketing to the Federal Farm Board in 1929.

In about 1915, the Federal Office of Markets and Rural Organization coöperated with the Ohio College of Agriculture and the Ohio State Grange in an intensive survey of the social activities of the Grange. In about 1917, programs for meetings of community organizations were prepared by the Federal unit and supplied in large quantities to coöperating State agencies. For example, such programs were furnished to 1200 school and civic leagues in Virginia, in coöperation with the Extension Division of the Virginia Polytechnic Institute. In 1917 and 1918, a general study of State and county fairs was made and lists prepared. Extracts from State laws were compiled and furnished and, in 1917, a publication on the community fair was issued (87—870).

The Division of Farm Population and Rural Life and its predecessor units have coöperated with State and local official agencies in discussions of better fire protection in rural communities. In 1920, suggestions for a State law providing for the organization of farmers' mutual fire insurance companies was published by the Federal Department (91—77). In 1929, the Bureaus of Agricultural Economics, Agricultural Engineering, and Chemistry and Soils coöperated in a discussion of fire-protection construction on the farm (87—1590) and in 1930 on fire safeguards for the farm (87—1643). In 1931, a discussion of rural community fire departments was published (87—1667) by the Bureau of Agricultural Economics, covering eighty such departments, of which many were found in California, a State which has made the most progress in this direction, and in which considerable coöperation between municipal and rural official agencies has been developed.

Since the expansion of funds for research in rural sociology, as provided increasingly by the Federal Purnell Act of 1925, the volume of coöperative research in this field has steadily increased. This may be illustrated by single studies made in Montana and Pennsylvania, and series of studies made in Virginia, Washington, and Wisconsin, in most of which the Federal Division of Farm Population and Rural Life has coöperated. In Montana, coöperation with the Experiment Station covered the rural community club (47—224) and, in Pennsylvania, the organizations affecting farm youth in a single township (66—265).

In Virginia, a series of five coöperative publications issued by the Experiment Station between 1927 and 1933 covered rural organizations in relation to rural life (125—256) and membership relations in community organizations (125—287), both with regard to member attitudes; young people's organizations, the 4-H clubs (125—274); and the negro church (125—273) and negro organizations and leadership in relation to rural life (125—290), the two latter coöperative only between the Virginia Station and the State College for Negroes.

In Washington, the coöperative studies of rural social organizations were published by the State Station for Whitman County (128—203), Whatcom County (128—215), and Clark County (128—225) from 1926 to 1928. In Wisconsin, the State Station,

between 1924 and 1929, published coöperative studies of origin and development of rural religious organizations (134—60), special interest groups in rural society (134—84), and rural organizations and the farm family (134—96).

RURAL EDUCATION

The whole plan of public education is a contribution to the sociological development of the individual. Some coöperative features of rural education already have been discussed in the chapter on Agricultural Education, especially that part of it relating to the Federal-State Agricultural Extension Service. This nation-wide organization is probably the single largest force in rural sociology in this country, for its activities tend to produce changes in the thinking and practices of the farmers and the farm homemakers, and perhaps even more in the farm boys and girls. In Wisconsin, the University of Wisconsin coöperated with the States Relations Service in an early study of economic forces which influence education, published (134—40) in 1916.

In Montana, a study of public-school dormitories for rural children was made jointly by the State College Departments of Home Economics and Rural Life and published (47—201) in 1927. Another study, of the county library, in coöperation with the Federal Division of Farm Population and Rural Life and with the assistance of the librarian at the State University, was published (47—219) in 1929.

In Nebraska, the Experiment Station and the Federal Office of Farm Management and Farm Economics coöperated during 1920 and 1921 in a survey of reading matter in Nebraska farm homes (50—180). In South Dakota, the State College Department of Rural Sociology coöperated with the Federal Division of Farm Population and Rural Life during 1926 and 1927 in a study of equalizing library opportunities, published by the Station in 1928. A study of high-school education of farm boys and girls in South Dakota was begun by the same two agencies in 1925 and completed (70—250) in 1929.

RURAL POPULATION

In 1920, the Section of Rural Life Studies in the Federal Office of Farm Management and Farm Economics began coöperative stud-

ies with State colleges of agriculture on the analysis of the rural population of individual counties into primary groups in order to learn the character of a country community. The work in New York covered the period from 1855 to 1925. The Wisconsin study, covering Dane County, was published (134—51) in 1921, and that in North Carolina, made in Wake County (58—245) in 1922. The Federal Division of Farm Population and Rural Life coöperated with the Federal Bureau of the Census in 1923 in a study of the farm population in eight counties.

In Missouri, the Experiment Station Department of Rural Sociology, in coöperation with the Federal Division of Farm Population and Rural Life, made a study of rural population groups, which was published by the Station (46—74) in 1925. Similar studies, conducted coöperatively in different counties, were tabulated for use by the collaborating Federal and State agencies. A later coöperative study with the Department of Agricultural Economics of the Iowa State College covered the composition and changes of the population of that State, and was published by the State Station (29—275) in 1930. A similar later study of the sources, changes, and present condition of the population of Missouri, made jointly by the Federal and State agencies, was published by the Missouri Station (46—188) in 1932. Studies of the migration of farm population are discussed under Rural-Urban Relations.

A coöperative study of what farmers think of farming was made in South Dakota in 1926 by the Experiment Station Department of Rural Sociology and the Federal Division of Farm Population and Rural Life (70—223). In 1931, the Minnesota Station published (40—288) a coöperative study of the relation of variations in the human factor of the farm enterprise to its financial returns under joint authorship with the Federal Division of Farm Management and Costs.

Rural Leadership

In the general surveys of rural communities which characterized the earlier studies in rural sociology, many facts regarding rural leadership and its influence were brought out. In one community study, coöperative between Cornell University and the Federal Office of Farm Management and Farm Economics, these facts were

so striking that they were published by the Federal Department of Agriculture (86—984) in 1921 under the title, *The National Influence of a Single Farm Community*. In Montana, the Experiment Station coöperated with the Federal Division of Farm Population and Rural Life, assisted by the Minnesota Station, in a study of rural contributions to urban leadership in Montana, published (47—262) in 1932. In Washington, the Station Division of Farm Management and Agricultural Economics, in coöperation with the Federal Division, published on local rural leaders in that State (128—257) in 1931.

Farm Labor

Only a few coöperative studies of farm labor and wages have been made from other standpoints than that of crop production, already discussed in the Section on Farm Management in this chapter. A study of farm labor in Wisconsin, made in 1917 and 1918 in coöperation with the Federal Office of Farm Management, was published by the State Station (133—316) in 1920. The Minnesota Station, assisted by the Federal Bureau of Crop Estimates, made a survey of the wages of farm labor (41—4) in 1922.

During the emergency of the World War from 1917 to 1919, there was widespread Federal and State coöperation in maintaining an adequate supply of farm labor. The chief Federal agencies concerned at the beginning were the Office of Farm Management in the U. S. Department of Agriculture and the Federal Department of Labor. The State agencies included the State agricultural colleges, State departments of agriculture, State commissioners of labor, and State committees on food production and conservation. The Office of Farm Management coöperated with the different States in furnishing men qualified to help in organizing State plans for farm labor. Farm-health specialists conducted educational campaigns and acted as clearing houses in the farm-labor situation. During demobilization in 1919, all Federal agencies, including the U. S. Employment Service, coöperated with the War and Navy Departments and all State agencies in placing returning soldiers and sailors. The Office of Farm Management maintained representatives in eleven demobilization camps to give needed information to the men.

Farm Youth

As previously mentioned, the Federal-State Agricultural Extension Service in its promotion and supervision of boys' and girls' clubs, is an enormous sociological force in its influence on farm youth. Much material accumulated by this coöperative enterprise will be found in its *Annual Reports* and its special publications on the work of the 4-H Clubs. Some studies of the educational opportunities of rural young people have been mentioned under Rural Education in this chapter. A few special sociological studies are mentioned here.

The Federal Bureau of Agricultural Economics, in 1926, published a bibliography of material on the subject of farm youth (99—17). In Missouri, the Station Department of Rural Sociology, in coöperation with the Federal Division of Farm Population and Rural Life, made a study of the community relations of young people (46—110) in 1927. In New York, the Department of Rural Organization of Cornell University coöperated with the Federal Division in a study (57—560) of the income, savings, and work of boys and girls on New York farms in 1930.

Most of the publications concerning the 4-H Clubs have appeared in the series issued by the State extension divisions. In a few instances, they have been published by the State experiment stations instead. In Virginia, the Station Division of Rural Sociology and the Department of Sociology of the State Teachers' College coöperated in a study of young people's organizations in relation to rural life, with special reference to 4-H Clubs (125—274), jointly authored in 1930, with an acknowledgment of assistance from the Extension Division, the Divisions of Agricultural Education and Home Economics in the State Department of Agriculture, and the Federal Division of Farm Population and Rural Life. In West Virginia, a coöperative study of 4-H Club work, made by the State College of Agriculture in coöperation with the Federal Division, was published in 1931 (130—241).

RURAL-URBAN RELATIONS

The relations between town and country have long been a subject of discussion, investigation, and writing. For a long time antago-

nism rather than coöperation was assumed to be the attitude of each of these interdependent communities toward the other. In recent years, much attention has been given to improving these relations and changing the historic attitude to one of mutual helpfulness. A few general studies have been published, but most of the studies of these matters may be arranged in two groups, one covering migration to and from the farm and the other covering trade and service relations. Studies of the influence of rural leadership have been given heretofore, under the discussion of Rural Population.

In Michigan, the Department of Sociology of the Michigan State College and the Federal Division of Farm Population and Rural Life coöperated in a general study of town and country relations, published (37—181) in 1928. In New York, coöperative studies were made from 1928 to 1931 by the Cornell University Department of Rural Organization and the Federal Division on the relation of the open-country population to villages and cities and published separately for Genesee County (57—583) and Onondaga County (57—584), both in 1934.

Migration to and from the Farm

In general, there is a fairly steady flow of population from rural areas to urban centers in times of prosperity. This flow is greatly slowed down and sometimes reversed in times of industrial depression, when urban labor demands are sharply decreased and the possibility of raising at least a food supply on the farm proves very attractive to unemployed urban residents. In addition, there is the perennial "back to the land" movement, especially vigorous after a war, when the question of what to do with demobilized soldiers and sailors is acute. Some phases of this have been discussed under Land Settlement and Colonization in the present chapter.

One of the early studies made by the Federal Office of Farm Management and Farm Economics in coöperation with the Colleges of Agriculture of Maryland and West Virginia in 1919 and 1920 related to the migration of young people from the farm and the remedies therefor (104—1920:572). Shortly thereafter, a study was made in Wisconsin, by the Federal agency, of a hundred families which had moved from farms to towns. From 1924 onward, at least for several years, annual surveys were made of the movements

to and from farms, county by county, with some coöperation from Federal and State agencies, the results being mimeographed.

In Oklahoma and Washington, the Station Division of Agricultural Economics and the Federal Division of Land Economics co-operated in studies of the economic and social aspects of mobility in farming (62—195) and of farm migration in selected communities (128—233), two studies, both published in 1929. Similar studies were made in Iowa, Missouri, Montana, North Dakota, and Vermont.

In New York, a study of rural homes of city workers and the urban-rural migration was made by the New York State Commission on Rural Homes in coöperation with the Monroe County Regional Planning Board and published by the Cornell University Station (57—595) in 1934. In North Carolina, the State Station published (58—295) in 1934, the results of a study of rural-urban migration, based on census data of 1920 and 1930, with the coöperation of the Federal Bureau of the Census in tabulation and of the Federal Division of Farm Population and Rural Life in suggestions and illustrations.

Late in 1934, the Federal Division of Farm Population and Rural Life issued a significant publication on interstate migration, consisting of a series of maps showing for each State the State of origin of migrants to, and State of destination of migrants from the given States, as compiled from the census data for each decade from 1870 to 1930 (21).

Trade and Service Relations

The commercial bonds between towns and cities and surrounding rural communities are the largest and most important of all rural-urban relations, and form a great part of the material in the general studies discussed above. Some studies have been devoted entirely to these business relations.

A study of the function of farmers' trade and service centers was made by the Federal Office of Farm Management and Farm Economics and Division of Farm Population and Rural Life in co-operation with agencies in Louisiana, Minnesota, and Wisconsin, from 1921 onward. The Louisiana study was conducted in coöperation with Tulane University and the results were published as a

research bulletin of that institution under the title, *Some Factors in Town and Country Relationships*. Minnesota studies of the services of rural trade centers in the distribution of farm supplies, conducted by the Minnesota Station Division of Agricultural Economics and the Federal Division of Farm Population and Rural Life, were published (40—249) in 1928. A later study of farm-trade centers in Minnesota from 1905 to 1929 was made by a committee representing the Division of Farm Management and Agricultural Economics of the Minnesota Station, the School of Business Administration and the Department of Political Science of the University of Minnesota, and the League of Minnesota Municipalities, and was published by the Station (40—269) in 1930. The Wisconsin studies of service relations (134—58) and service institutions (134—66) for town and country were published by the Wisconsin Experiment Station in 1923 and 1925.

In New York, the Department of Rural Organization of Cornell University and the Federal Division of Farm Population and Rural Life began a series of social and economic studies in rural areas in 1925, two of which belong to trade relations. One covered village service agencies (57—493), and another the relation of cities and larger villages to changes in rural and social areas in Wayne County, published (57—582) in 1934. In Oklahoma, the Station Division of Agricultural Economics and the same Federal Division coöperated in a study of the competition between the city of Enid and the rural villages for farmer trade in Garfield County in 1926—27, published (62—194) in 1930. In South Dakota, the Station Department of Rural Sociology coöperated with the Federal Division in a study (70—274) of town-country trade relations from 1901 to 1931.

THE FARM HOME

Under this heading are arranged those studies concerned with the relation of the farm home to the farm business, housing facilities, costs and standards of living, and the use of time by farm homemakers. Extensive coöperative studies have been made of living standards and, in recent years, much attention has been given to coöperative studies of the use of time.

As noted previously, the coöperative Federal-State Agricultural Extension Service is one of the chief agencies interested in the

solving of rural sociological problems. Its home-demonstration agents and boys' and girls' club agents have been potent influences in farm homes since the creation of the Extension Service in 1914. In 1927, the Federal Department of Agriculture published a ten-year review of home-management extension (90—17), covering the years from 1914 to 1924. It contained a discussion of home-management surveys in nearly three-fourths of the States, and represented coöperation by the departments of home economics, farm management, and rural engineering of various State colleges of agriculture and by the Federal Division of Farm Population and Rural Life, the Federal Bureau of Home Economics, and other agencies, as well as the Extension Service itself.

In Minnesota, a local coöperative study of the relation of the farm home to the farm business was made by the Divisions of Home Economics and Agricultural Economics of the State Experiment Station and published (40—279) in 1931.

Farm Housing

Some discussion of farm housing has been presented in the section on Farm Structures in the chapter on Agricultural Engineering.

In Nebraska, the Station Division of Agricultural Economics co-operated with the Federal Office of Farm Management and Farm Economics and its successor in various rural surveys from 1919 onward. One of the subjects was housing and house-operation costs on Nebraska farms, published by the Station (50—264) in 1931.

In December, 1931, the President's Conference on Home Building and Home Ownership was held in Washington, D. C. It created a large number of committees to deal with the various elements of the problem. The committee members were selected from Federal and State administrative and research agencies as well as from numerous private organizations. The Committee on Farm and Village Housing contained many representatives from the U. S. Department of Agriculture and the State colleges of agriculture, including one each from the Federal Bureaus of Agricultural Economics, Agricultural Engineering, and Home Economics.

The Farm Structures Section of the Division of Agricultural Engineering prepared mimeographed circulars for the use of the conference, one discussing foundations for farm and village houses.

The Bureau of Agricultural Economics prepared an extensive bibliography of recent material on farm and village home building and ownership, including construction, protection from fire and insect injury, and the installation of water, heating, electric, and sewage systems. The findings of the conference were published in a series of eleven volumes (67), three of which, volumes 7, 8, and 11, respectively, were concerned with Farm and Village Housing, Housing and the Community, including home repair and remodeling, and Housing Objectives and Programs.

A research project on means of increasing efficiency and comfort in the farm home grew out of the President's Conference. It was begun in 1932 by the Section of Farm Structures in the Federal Bureau of Agricultural Engineering, in cooperation with the Bureau of Home Economics. In 1933, a survey of farm-house conditions was made in Alabama, Georgia, Michigan, Ohio, North Carolina, and South Carolina, in cooperation with representatives of the State Agricultural Experiment Stations and Extension Divisions. As a result of the survey, designs for farm houses were developed which embodied specifications for increased efficiency, convenience, and comfort.

Costs and Standards of Living

Federal agencies began cooperation with the State colleges of agriculture in studies of costs and standards of living in farm families as early as 1914 and 1915. Because of the volume of this cooperation, the discussion is presented by different geographical areas. Certain general studies, however, cover more than one of these geographical areas, and they are discussed at this point.

In 1926, the Federal Division of Farm Population and Rural Life published a summary of studies made of standards of living of farm families (86—1466) comprising a social and economic study of nearly 3000 families from selected localities in eleven States. The cooperating State agencies included the Departments of Economics and Sociology or the Agricultural Extension Services or both in the Alabama Polytechnic Institute, the Connecticut, Iowa, and Kansas State Agricultural Colleges, the Universities of Kentucky, Missouri, New Hampshire, and Vermont, and some private educational institutions. The Federal Bureau of Home Eco-

nomics coöperated in the Vermont study. In 1927, the Department published studies of family nutrition needs based on dietary scales and standards (89—8), which represented the results of a six-year study conducted coöperatively by the Bureaus of Agricultural Economics and Home Economics. A discussion of adequate diets for families with limited farm incomes was published (94—113) under joint authorship of the Bureau of Home Economics and the Office of Coöperative Extension Work in 1931.

In 1930, the Federal Bureau of Agricultural Economics issued a bibliography on rural standards of living (99—32). In 1932, the Federal Department of Agriculture published a series of short papers under the general title "Living Standards on the Farm" (96—1932:549), mostly contributed by the Bureau of Home Economics and summarizing results of investigations, part of which had been coöperative.

New England and North Central States.—Studies made coöperatively in Connecticut, New Hampshire, and Vermont are recorded above (86—1466). In Vermont, the farm-management specialists of the Experiment Station and Extension Division joined with the Department of Home Economics of the College of Agriculture in a later study of standards of living on owner-operated farms, published (124—340) in 1932.

An early study (in 1919) was made in New York by the Cornell University Department of Rural and Social Organization with financial assistance from the Office of Home Economics in the Federal States Relations Service and the Section of Rural Life Studies in the Federal Office of Farm Management and Economics, and published by the Cornell Station (57—423) in 1923. A similar study of family living in Livingstone County, New York, was published (86—1214) in 1924, under joint authorship of the two Federal agencies.

A study of farm costs of living from 1905 to 1914 was made in coöperation with the Federal Bureau of Statistics and published by the Minnesota Experiment Station (40—162) in 1916. A later study of how farm-family incomes are spent (40—234), made in 1924 and 1925, was coöperative only between the Station Departments of Sociology and Agricultural Economics. There was a study also of the incomes and expenditures of village and town families

(40—253), in which the Sociology Department was assisted by extension specialists. In Iowa, the Rural Sociology section of the Experiment Station, in coöperation with the Federal Division of Farm Population and Rural Life, published under joint authorship on the costs (29—237) and standards of living (29—238) on Iowa farms. In Ohio, the Federal Division of Farm Population and Rural Life, in coöperation with the Division of Farm Management and Costs and the Ohio Experiment Station, made a study in 1928 of conditions of planning and living in an area of low income, including farm abandonment and part-time employment in coal mines. In Ohio, also, records of family living expenditures on 187 farms were taken from 1926 to 1928, by coöperation between the Departments of Agricultural Extension, Home Economics, and Rural Economics of the Ohio State University, and published by the Station (61—468) in 1930.

Southern States.—In Kentucky, a study was made of the cost of living and population trends in Laurel County by the Experiment Station (32—301) in coöperation with the Federal Division of Farm Population and Rural Life. A study of farm management and income in the same county was published under joint authorship by the Kentucky Station (32—305) and the Federal Division of Farm Management and Costs, with acknowledgment of assistance from the Federal Divisions of Land Economics and Farm Population and Rural Life, both bulletins appearing in 1930. A similar study of the standard of living of farm families in Grayson County (32—316) also was coöperative with the Division of Farm Management and Costs. The Missouri Station and the Federal Office of Farm Management coöperated in obtaining the labor data for the study of the cost of family living on Missouri farms (45—213), published in 1924. A later coöperative study by the Missouri Departments of Rural Sociology, Home Economics and Agricultural Economics, on the social, economic, and homemaking factors of farm living, was published by the Station (45—148) in 1930, with coöperation also from the Federal Bureau of Agricultural Economics.

In North Carolina, studies of the living conditions of farm tenants, conducted coöperatively by the Federal Division of Farm Population and Rural Life, the University of North Carolina, and

a special committee appointed by the governor, were published by the University. In South Carolina, the Division of Foods and Nutrition in the Federal Bureau of Home Economics coöperated with the South Carolina Agricultural Extension Division and the South Carolina State Board of Health in a study of the relation of food supply and the incidence of pellagra in farm families, published (89—333), in 1932.

The Federal Division of Land Economics, in coöperation with similar units in the Colleges of Agriculture of Kentucky, Tennessee, and Texas, made an extensive study of the relation between ability to pay and the standard of living of nearly a thousand white families in those States. The Texas data were published (86—1068) with those on farm ownership and tenancy, in 1922, and those for Kentucky and Tennessee (86—1382) in 1926.

In January, 1935, a comprehensive publication on economic and social problems and conditions of the southern Appalachians was published (94—205) by the Federal Bureaus of Agricultural Economics and Home Economics and the Forest Service, in coöperation with the Office of Education in the Department of the Interior and the Agricultural Experiment Stations of Kentucky, Tennessee, Virginia, and West Virginia. Acknowledgment of coöperation is prominently displayed on the cover and title pages and the official relations set forth in detail on the inside of the title page.

Great Plains and Western States.—In Nebraska, during 1920 and 1921, the Federal Division of Farm Management and Farm Economics coöperated with the Experiment Station in a study of comparative living conditions in farm homes of owners, part-owners, and tenants (50—191). A summary of the standard of living in the Nebraska farm home, based on the above publication of the survey results, was issued by the Nebraska Station (50—267) in 1932. The Nebraska Station Divisions of Rural Sociology and Home Economics made a study of the cost of feeding a farm family (50—219), published in 1927.

From 1923 to 1931, the North Dakota Experiment Station Division of Farm Management and Rural Organization coöperated with the Federal Division of Farm Population and Rural Life in a continuing study of incomes and cost of living for farm families in that State (60—271).

In Idaho, the Station Department of Home Economics took part in the general Federal-State coöperative study of food consumption and food expenditures in relation to living standards and family income, published (24—165) in 1929. In Utah, the Agricultural Experiment Station, the Extension Division, and the Department of Home Economics coöperated in a study of family living expenditures in Summit County, published (123—232) in 1931.

Use of Time by Homemakers

In recent years, the Federal Bureau of Home Economics has coöperated with similar units in the State colleges of agriculture on a study of the use of time by homemakers on farms. In Idaho (24—146) and Montana (47—271) the studies were conducted by means of plans and blanks furnished by the Federal Bureau, and published in 1927 and 1933. An earlier study by the Nebraska Station, made chiefly in 1924, was in coöperation with the Federal Bureau of Agricultural Economics with some assistance from the Station Department of Home Economics, and published (50—230) in 1929. The Oregon (63—256), Washington (128—234), and South Dakota (70—247) Stations all coöperated with the Federal Bureau of Home Economics and published in 1929 and 1930.

The publications listed in the Literature Cited at the end of this chapter which have been cited in this section on Rural Sociology are Nos. 21, 24, 29, 32, 37, 40, 41, 45, 46, 47, 50, 57, 58, 60, 61, 62, 63, 66, 67, 70, 86, 87, 89, 90, 91, 94, 96, 98, 99, 104, 123, 124, 125, 128, 130, 133, and 134.

8. SUMMARY OF COÖPERATION

AGRICULTURAL ECONOMICS includes crop and livestock estimates and statistics, farm management and costs of production, marketing of agricultural commodities and products, agricultural finance, land-use economics, and the problems of rural sociology. The gathering of agricultural statistics goes back nearly a century. The others are relatively new subjects for teaching, research, and extension, practically all having developed in the last thirty years. Because of rapid and fundamental changes in the agricultural enterprise of America, especially in the last fifteen or twenty years, the impor-

tance of the problems, the official activities, and the coöperation between agencies, is very large in proportion to the time period covered.

The principal official agencies involved are the International Institute of Agriculture, supported coöperatively by many nations; the Bureau of Agricultural Economics, the Extension Service, the Bureau of Home Economics, and recently the Agricultural Adjustment Administration, all in the United States Department of Agriculture; the Bureau of the Census in the United States Department of Commerce; the Farm Credit Administration and antecedent units; the Departments of Agricultural Economics and Home Economics, and the Extension Services of the State Colleges of Agriculture; and the various coöperative Federal-State Crop Reporting Services and State marketing units in the State Department of Agriculture or elsewhere. Less important Federal and State agencies are those concerned with soil survey, agricultural engineering, reclamation, education, and taxation. There is a large and increasing volume of coöperation between and among these Federal and State agencies.

CROP AND LIVESTOCK ESTIMATES AND STATISTICS

The data gathered coöperatively on crops and livestock include both annual percentage estimates and less frequent actual enumerations of acreage, numbers, and production; special surveys of geographical distribution and production of individual commodities; outlook reports showing intention to produce and probable market demand; tabulation and analyses of commodity and product prices on the farm and in trade and commerce; and miscellaneous statistics on freight rates, farm incomes, etc.

The principal coöperating agencies concerned are the International Institute of Agriculture at Rome, the Divisions of Crop and Livestock Estimates and Statistical and Historical Research in the Federal Bureau of Agricultural Economics; the Division of Agriculture in the Federal Bureau of the Census; and the Federal-State Crop and Livestock Reporting Service, mostly in the State Departments of Agriculture, but sometimes with the State College of Agriculture. Minor agencies include the various statistical and commodity-marketing units in these Federal and State institu-

tions, and the Departments of Agricultural Economics in the State Colleges. The Post Office Department coöperates fully in the distribution of special schedules through its rural carriers in selected areas. The Division of Crop and Livestock Estimates coöperates widely with subject-matter Bureaus and Divisions, in making special surveys of geographic distribuion and production of individual commodities.

FARM MANAGEMENT AND COSTS

Studies in farm organization and management, and in production costs, date from 1902 in the Federal Department and State Colleges of Agriculture. By ten years thereafter coöperative activities were well begun and in the last twenty years most of the Federal research in farm management and cost accounting has been in co-operation with State College units, and has covered most of the States. From 1921 to 1927 about 60 per cent of the more than 50 Federal bulletins on these subjects represented coöperative studies.

The research projects have included not only general farm organization and management but also numerous studies of many individual crop and livestock enterprises, including honeybees. For some of the larger crop enterprises, the studies included crop labor requirements and costs. They also have covered farm machinery and farm power, including the clearing of land by different methods.

The principal coöperating agencies have been the Division of Farm Management and Costs in the Federal Bureau of Agricultural Economics, and their respective predecessor units, and the corresponding Section or Division in the College and Station Department of Agricultural Economics in the State Land-Grant Colleges.

MARKETING AGRICULTURAL COMMODITIES

The principal coöperative activities have been studies of coöperative marketing by producers, promotion of licensed warehousing and other storage, the establishment of commodity and container classes, grades, and standards; training of inspectors; promotion of terminal and shipping-point inspection and certification; and a wide range of studies in the marketing problems of many crop and livestock products.

Federal marketing activities are about forty years old, as a Section of Foreign Markets was established in 1894. For the first twenty years, the few units were mostly noncoöperative. Between 1913 and 1917 they were consolidated in what has become the Bureau of Agricultural Economics, and the expanding work rapidly become coöperative. The eight present commodity Divisions of that Bureau are Grain; Hay, Feed, and Seed; Cotton; Tobacco; Fruits and Vegetables; Livestock, Meats, and Wool; Dairy and Poultry Products; and Warehousing. The Division of Foreign Agricultural Service operates abroad. State agencies include the State College Departments of Agricultural Economics, and Bureaus of the State Departments of Agriculture. Subject-matter agencies (production and protection) both Federal and State, coöperate extensively. In 1920 the Federal Bureau was coöperating with 32 States, the coöperation being with the State College in 21, with the State Department in 7, and with both institutions in 4.

LAND ECONOMICS

From the standpoint of agriculture, land economics considers land classification, reclamation, and use for crop and livestock production. From the standpoint of economics, it is concerned with basic trends in production, population, and consumption; with land deterioration, conservation, and reclamation; with land prices, taxes, and values; with land settlement, ownership, and tenancy; and with interest rates, mortgage indebtedness, and agricultural credit. In scope, it reached back to statistics, farm management, and product marketing, and forward to agricultural finance and some phases of rural sociology.

The principal Federal agencies concerned with land economics are the Division of Land Economics in the Bureau of Agricultural Economics, the new Farm Security Administration, the Agricultural Adjustment Administration, and the National Resources Committee. The principal State agencies are the State College Department of Agricultural Economics and the State Planning Board or Commission.

Other coöperating Federal and State agencies are those concerned with agricultural engineering, agricultural extension, forestry, geological survey, grazing, planning, plant industries, public

domain, reclamation, soil survey and conservation, and wild-life development.

While the subject of land economics is very new, it has become crucially important under the impetus of the agricultural and general depressions. As a result, a very large volume of activity has developed and the proportion of coöperation has been gratifyingly large and is increasing rapidly.

AGRICULTURAL FINANCE

Agricultural finance comprises agricultural insurance, agricultural credit, interest rates, mortgage indebtedness, and taxation. Credit is of three classes; long-time or mortgage credit, intermediate, and short-term or production credit.

The principal Federal agencies are the Division of Agricultural Finance in the Bureau of Agricultural Economics, the former War Finance Corporation and Federal Farm Board, and the more recently created Farm Credit Administration, Agricultural Adjustment Administration, and Farm Security Administration. From 1919 onward to 1932, emergency seed and feed loans were made by the Department of Agriculture, under authority of Congress, in areas of disastrous droughts, floods, hurricanes, or insect outbreaks. Within the States, the research agency is the State College Department of Agricultural Economics. Other State agencies include the Tax Commission, the Banking Commission or Department of Banking (and Corporations), and, in a few States, some special agency for making farm-home loans, or providing State-financed crop insurance. A large volume of coöperative activity has developed.

RURAL SOCIOLOGY

Rural sociology is the most recent component part of agricultural economics. It includes the rural community, farm population (including youth) sources and movements, rural organizations, education, labor, and housing, and rural-urban relations, as well as the farm home and its relation to the farm business.

The principal Federal agency has been the former Office of Markets and Rural Organizations (1914) and the present Division of Farm Population and Rural Life. There has been coöperation by the Division of Farm Management, the Extension Service, and the

Bureaus of Home Economics and Agricultural Engineering. The principal State agencies have been the State College Departments of Agricultural Economics or Rural Sociology and Home Economics, and any units concerned with farm business affairs in the State Department of Agriculture. Federal and State agencies concerned with education have helped. Extensive coöperation has developed, especially since the Purnell Act, in 1925, provided the State Experiment Stations with Federal funds which might be used for studies in rural sociology and home economics. By 1928, there were 28 coöperative Federal-State projects and by 1930 a school of methods in research.

Studies of the social aspects of the rural community included community buildings and social, religious, and business organizations, including coöperatives and farmer attitudes toward them. Studies of rural population have covered the source, composition, and change of primary groups; rural leadership; migration; and farmer attitudes and aptitudes in regard to farming. Special studies of farm youth included work and savings, community relations, and organizations, especially 4-H Clubs. Rural education covered physical and economic factors, library facilities, and home reading matter. Rural-urban relations covered social, trade, and service relations, and migrations to and from the farm. Research on the farm home included its relation to the farm business, farm housing, costs and standards of living, and use of home makers' time.

9. LITERATURE CITED

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4. Association of Land-Grant Colleges and Universities. Proceedings of the —th Annual Convention of the Association of Land-Grant Colleges and Universities. 24th (1910)-, 1911-.

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13. Delaware Agricultural Experiment Station. Bulletins 1-, 1888-.

14. Ezekiel, Mordecai and Louis H. Bean. Economic bases for the agricultural adjustment act. iv, 67 p., U. S. Dept. Agric., unnumbered publ., December, 1933.

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26. Illinois Agricultural Experiment Station. Bulletins 1-, 1888-.

27. Illinois Agricultural Experiment Station. Circulars 1-, 1897-.

28. Indiana Agricultural Experiment Station. Bulletins 1-, 1885-.

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29. Iowa Agricultural Experiment Station. Bulletins 1-, 1888-.

30. Iowa Agricultural Experiment Station. Research Bulletins 1-, 1911-.

31. Kansas Agricultural Experiment Station. Bulletins 1-, 1888-.

32. Kentucky Agricultural Experiment Station. Bulletins 1-, 1885-.

33. Louisiana Agricultural Experiment Station. Bulletins (Second Series) 1-, 1890-.

34. Maine Agricultural Experiment Station. Bulletins (Second Series) 1-, 1889-.

The designation "Second Series" was dropped after Bulletin 25. Bulletins of this series, with the usual exception of those on inspection work, were reprinted in the annual reports of the station from 1893 to 1898, inclusive, and in the annual reports of the Maine Board of Agriculture (after 1901, Commissioner of Agriculture) from 1893 to 1906, inclusive.

35. Maryland Agricultural Experiment Station. Bulletins 1-, 1888-.

36. Massachusetts Agricultural Experiment Station. Bulletins 1-, 1883-.

37. Michigan Agricultural Experiment Station. Bulletins 34-, 1888-.

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38. Michigan Agricultural Experiment Station. Special Bulletins 1-, 1894-.

39. Michigan Agricultural Experiment Station. Technical Bulletins 1-, 1908-.

40. Minnesota Agricultural Experiment Station. Bulletins 1-, 1888-.

41. Minnesota Agricultural Experiment Station. Technical Bulletins 1-, 1921-.

42. Mississippi Agricultural Experiment Station. Bulletins 1-, 1888-.

43. Mississippi Agricultural Experiment Station. Joint Bulletin 1, 1926.

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51. Nebraska Agricultural Experiment Station. Research Bulletin 1-, 1913-.
52. Nebraska Agricultural Experiment Station. Circulars 1-, 1917-.
53. Nevada Agricultural Experiment Station. Bulletins 1-, 1888-.
54. New Hampshire Agricultural Experiment Station. Bulletins 1-, 1888-.
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57. New York (Cornell) Agricultural Experiment Station. Bulletins 1-, 1888-.
58. North Carolina Agricultural Experiment Station. Bulletins 1-, 1877-.
- Numbers were first applied to No. 57 and lists vary slightly as to the publications comprised in the first 56 numbers.
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60. North Dakota Agricultural Experiment Station. Bulletins 1-, 1891-.
61. Ohio Agricultural Experiment Station. Bulletins (Second Series) 1, 1888-.
62. Oklahoma Agricultural Experiment Station. Bulletins 1-, 1891-.
63. Oregon Agricultural Experiment Station. Bulletins 1-, 1889-.
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65. Pacific Northwest Regional Planning Commission. Proceedings of the First Pacific Northwest Regional Planning Conference at Portland, Oregon, March 5, 6, and 7, 1934. 131 p., unnumbered publ., Pacific Northwest Regional Planning Commission, Portland, Oregon. 1934.
66. Pennsylvania Agricultural Experiment Station. Bulletins 1-, 1887-.
67. President's Conference on Home Building and Home Ownership. 11 Volumes. (Washington: National Capital Press, 1932)
68. Rhode Island Agricultural Experiment Station. Bulletins 1-, 1889-.
69. South Carolina (Clemson College) Agricultural Experiment Station. Bulletins 1-, 1891-.
70. South Dakota Agricultural Experiment Station. Bulletins 1-, 1887-.
71. South Dakota Agricultural Experiment Station. Circulars 1-, 1920-.
72. Taylor, Edward T. The use of our remaining public domain. Congressional Record 78:161-63, Jan. 5, 1934. 73d Congress, 2nd Session.
73. Texas Agricultural Experiment Station. Bulletins 1-, 1888-.

74. U. S. Committee on Conservation and Administration of the Public Domain. Report of the Committee on the Conservation and Administration of the Public Domain. January, 1931. Transmitted to the President of the United States in pursuance of the act of April 10, 1930. 85 p., 1 folded map. (Washington: Government Printing Office, 1931)

75. U. S. Congress, House of Representatives. The farm debt problem. U. S. Cong., 73d, 1st sess., H. doc. 9:1-54, 1933.

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83. U. S. Congress, Senate. Systems of rural coöperative credit. U. S. Cong., 62d, 2d sess., S. doc. 574:1-48, 1912.

84. U. S. Congress, Subcommittees of the Committees on Banking and Currency. Rural Credits. Joint Hearings before the subcommittees of the committees on banking and currency of the Senate and House of Representatives charged with the investigation of rural credits. U. S. Cong., 63d, 2d sess., Joint Hearings: Pts. 1-23, 1914.

85. U. S. Department of Agriculture. Report of the Secretary of Agriculture for the year ———. 1862-.

Report of the Commissioner, 1862-88; Report of the Secretary, 1889-. From 1862 to 1920, inclusive, and for 1922 and 1923, the reports of Chiefs of Offices, Divisions, and Bureaus are included with the report of the Secretary in a consecutively paged volume. For 1921 and 1924 to date, all these reports are issued separately each year, with separate paging.

86. U. S. Department of Agriculture. Department Bulletins 1-1500, 1913-29.

All Bureau series of publications were discontinued on June 30, 1913, and various Departmental series inaugurated on July 1. This series of *Department Bulletins* was succeeded by *Technical Bulletins* and *Miscellaneous Publications*, the issuance of which, however, began in 1927. The Department bulletins are designated simply as *Bulletins* until after No. 1100, when the word *Department* was inserted.

87. U. S. Department of Agriculture. Farmer's Bulletins 1-, 1889-.

88. U. S. Department of Agriculture. Statistical Bulletins 1-, 1923-.

89. U. S. Department of Agriculture. Technical Bulletins 1-, 1927-.

90. U. S. Department of Agriculture. Circulars 1-, 1927-.

Circulars in this series should not be confused with those in the series designated *Department Circulars* (Nos. 1-425, 1919-27), nor with those in the series designated *Miscellaneous Circulars* (Nos. 1-, 1923-).

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This series should not be confused with the series known as *Miscellaneous Circulars*, established in 1923 and still continuing, or with the series designated simply as *Circulars* (Nos. 1-, 1927-).

92. U. S. Department of Agriculture. Miscellaneous Circulars 1-, 1923-.

This series should not be confused with the series designated as *Department Circulars* (Nos. 1-425, 1919-27), or with the series designated simply as *Circulars* (Nos. 1-, 1927-).

93. U. S. Department of Agriculture. Leaflets 1-, 1927-.

94. U. S. Department of Agriculture. Miscellaneous Publications 1-, 1927-.

The different publications in this series range in size from 16mo or smaller up through 12mo, 8vo, and 4to, which means that bound sets are rarely complete. This series should not be confused with the concurrent series of *Miscellaneous Circulars*.

95. U. S. Department of Agriculture. Reports 1-117, 1862-1917.

Nos. 1-58 were issued 1862-98, without numbers. A list of titles and assigned numbers for this series was printed on cover pages 3 and 4 of No. 59, which was the first to bear a number.

96. U. S. Department of Agriculture. Yearbook of the Department of Agriculture, ——— [year]. 1894-.

From 1894 to 1928 the statistical and other data were for the year named in the title and the volume was published in the following year. Beginning with 1930 the year in the title is the year of issue and the contained data are for the previous year, a most confusing condition. Because of this change there is no volume bearing 1929 in its title.

97. U. S. Department of Agriculture, Agricultural Adjustment Administration. Agricultural adjustment. A report of administration of the Agricultural Adjustment Act, May 1933 to February 1934. xi, 393 p., charts 1-38, 1934.

98. U. S. Department of Agriculture, Bureau of Agricultural Economics. Annual Report of the Chief of the Bureau of Agricultural Economics. 1923-.

For earlier annual reports, see Office of Markets and Rural Organization for fiscal years, 1915-17; Bureau of Markets (Entry No. 105) for 1918-21; and Bureau of Markets and Crop Estimates (Entry No. 107) for 1922. (See also note under Entry No. 85.)

99. U. S. Department of Agriculture, Bureau of Agricultural Economics. Agricultural Economics Bibliography No. ———. No. 1-, 1925-.

100. U. S. Department of Agriculture, Bureau of Agricultural Economics. Atlas of American agriculture: physical basis, including land relief, climate, soils, and natural vegetation of the United States. Prepared under the supervision of O. E. Baker. 4 v. in 1, illus., maps, tables, diagrs. (Washington: Government Printing Office, 1936)

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101. U. S. Department of Agriculture, Bureau of Crop Estimates. Report of the Chief of the Bureau of Crop Estimates. 1915-20.

For earlier and later annual reports, see Entry No. 98. For immediately preceding annual reports, see Bureau of Statistics and Crop Estimates (Entry No. 117). For immediately succeeding annual reports, see Bureau of Markets and Crop Estimates (Entry No. 107).

102. U. S. Department of Agriculture, Office of Experiment Stations. Classified list of projects in agricultural economics and rural sociology. Federal bureaus, State agricultural experiment stations, and independent institutions. Year ended June 30, 1931. 157 p., unnumbered publ., mim., 8½" × 11", U. S. Dept. Agric., Off. Exp. Stat., 1932.

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For earlier and later annual reports, see Entry No. 98. For immediately preceding annual reports, see Office of Markets and Rural Organization. For immediately succeeding annual reports, see Bureau of Markets and Crop Estimates (Entry No. 107).

106. U. S. Department of Agriculture, Bureau of Markets. Documents 5-17, 1917-18.

For earlier issues, see Office of Markets and Rural Organization (Entry No. 108).

107. U. S. Department of Agriculture, Bureau of Markets and Crop Estimates. Report of the Chief of the Bureau of Markets and Crop Estimates. 1922.

For earlier and later annual reports, see Entry No. 98. For immediately preceding annual reports, see Bureau of Crop Estimates (Entry No. 101) and Bureau of Markets (Entry No. 105). For immediately succeeding reports, see Bureau of Agricultural Economics (Entry No. 98).

108. U. S. Department of Agriculture, Office of Markets and Rural Organization. Documents 1-4, 1915-17.

For later numbers, see Bureau of Markets (Entry No. 106).

109. U. S. Department of Agriculture, National Advisory Loan Committee. New credit for farmers. How farm communities may obtain Federal funds for agricultural credit corporations and how these funds supplement permanent farm credit facilities. 16 p., 4" × 9". (Washington: Government Printing Office, 1931)

110. U. S. Department of Agriculture, Bureau of Plant Industry. Bulletins 1-285, 1901-18.

111. U. S. Department of Agriculture, Bureau of Plant Industry. Circulars 1-132, 1908-13.

112. U. S. Department of Agriculture, Office of the Secretary. Circulars 1-183, 1896-1921.

This series should not be confused with other series of Circulars, issued by the Department.

113. U. S. Department of Agriculture, Office of the Secretary. Geography of the World's Agriculture. Folio, 149 pp., 10¼" × 12½", 206 figures, 2 folded maps (figs. AB), 1917.

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115. U. S. Department of Agriculture, Division of Statistics. Bulletins 1-103, 1890-1913.

116. U. S. Department of Agriculture, Bureau of Statistics. Report of the Chief of the Bureau of Statistics. 1904-13.

For earlier and later annual reports, see Entry No. 98. For immediately preceding annual reports, see Division of Statistics (Entry No. 114). For immediately succeeding annual reports, see Bureau of Statistics and Crop Estimates (Entry No. 117).

117. U. S. Department of Agriculture, Bureau of Statistics and Crop Estimates. Report of the Chief of the Bureau of Statistics and Crop Estimates. 1914.

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118. U. S. Department of Commerce, Bureau of the Census. Annual Report of the Director. 1903-.

119. U. S. Federal Emergency Administration of Public Works, National Planning Board. Circular Letters 1-13, 1933-34.

120. U. S. Federal Emergency Administration of Public Works, National Resources Board. Bulletins A, A-3, 1934.

121. U. S. Federal Emergency Administration of Public Works, National Resources Board. Circulars 1-7, 1934-35.

122. U. S. War Finance Corporation. ——— Annual Report of the War Finance Corporation for the year ended November 30, 19-. Reports 1-11, 1918-28. (Published also as House Documents, U. S. Congress.) Report of the Secretary of the Treasury on the War Finance Corporation (in liquidation) for the year ended November 30, 1929.

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124. Vermont Agricultural Experiment Station. Bulletins 1-, 1887-.

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129. Washington Agricultural Experiment Station. Popular Bulletins 1-, 1908-.

130. West Virginia Agricultural Experiment Station. Bulletins 1-, 1888-.

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135. Wyoming Agricultural Experiment Station. Bulletins 1-, 1891-.